DRAFT
SNOWSHOE MINE SITE
EXPANDED ENGINEERING EVALUATION/ COST ANALYSIS (EEE/CA)

Engineering Services Contract DEQ/MWCB 401027
Task Order Number 15

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TABLE OF CONTENTS

Page

LIST OF FIGURES

Following Page

LIST OF TABLES

Page

LIST OF APPENDICES

1.0 INTRODUCTION

Pioneer Technical Services, Inc. (Pioneer) prepared this Snowshoe Mine Site Expanded Engineering Evaluation/Cost Analysis (EEE/CA) for the Montana Department of Environmental Quality/Mine Waste Cleanup Bureau (DEQ/MWCB). This work was performed under Engineering Services Contract DEQ/MWCB 401027, Task Order Number 15.

1.1 PURPOSE AND OBJECTIVES

The primary purpose of this EEE/CA is to present analyses of reclamation alternatives applicable to the Snowshoe Mine Site in accordance with the National Contingency Plan (NCP). Additionally, site background, waste characteristics, Applicable or Relevant and Appropriate Requirements (ARARs), risk assessment, and preliminary development and screening of reclamation alternatives are presented.

The Snowshoe Mine Site is an abandoned hardrock mine site listed on the *Montana Department of State Lands (DSL) Abandoned Mine Reclamation Bureau, Abandoned Hardrock Mine Priority Sites List* (DEQ/MWCB-Pioneer, 1993). At the Snowshoe Mine Site, identified waste sources include mill tailings and waste rock that are located within the floodplain of Snowshoe Creek. The tailings material originated from an adjacent mill that processed ore from the Snowshoe Mine. The uncontained waste material is impacting water quality and sediment quality in Snowshoe Creek. The contamination is from heavy metals, primarily antimony (Sb), arsenic (As), cadmium (Cd), copper (Cu), lead (Pb), mercury (Hg), silver (Ag), and zinc (Zn).

The Snowshoe Mine Site is located approximately 16.5 miles southeast of Libby, Montana, in Lincoln County. It is located at the headwaters of the Snowshoe Creek drainage, which is part of the Cabinet Mountain watershed (Figure 1-1). The Snowshoe Mine is located in the Northwest Quadrant, Section 7 of Township 28 North, Range 31 West of the Montana Principal Meridian and covers approximately 9 acres (Figure 1-2). The project lies within the Kootenai National Forest and is adjacent to the Cabinet Mountain Wilderness area. The majority of the site is located on patented claims; however, a small portion overlaps onto the Kootenai National Forest (Figure 1-3).

The Snowshoe Mine Site is accessed by traveling south on Highway 2 from Libby, Montana, and then turning right onto Bear Creek Road (FR 278), an improved gravel road. Approximately 3 miles from Highway 2, FR 867 veers to the southwest until meeting the intersection with FR 6213, approximately 5 miles from FR 278. The Snowshoe Mine Site is located approximately 3 miles up FR 6213.

1.2 REPORT ORGANIZATION

This EEE/CA is organized into 11 sections. The contents of Sections 2 through 11 are briefly described in the following paragraphs:

SECTION 2.0: BACKGROUND: Presents a background description of the Snowshoe Mine Site including a detailed history of past mining and milling activities; geologic, hydrologic, and climatic characteristics of the site; the biological setting, such as the wildlife and fisheries resources and the vegetation indigenous to the area; threatened and endangered species concerns; and cultural setting issues.

SECTION 3.0: WASTE CHARACTERISTICS AND SUMMARY OF THE RECLAMATION INVESTIGATION: Describes Previous Investigations performed at the site including the 1988-1989 Reclamation Project, the 1993 Hazardous Materials Inventory, the 2002 Reclamation Investigation and the 2004 Repository Site Investigations conducted by MAXIM Technologies (MAXIM) and Pioneer. Characteristics of the wastes present at the site, volume estimates, and analytical data are also presented in this section.

SECTION 4.0: SUMMARY OF THE APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS: Presents the Montana State and Federal government requirements that are considered ARARs for the reclamation effort. Requirements discussed in this section are chemical-, location-, and action-specific in nature.

SECTION 5.0: SUMMARY OF THE RISK ASSESSMENT: Presents a summary of the baseline risk assessment performed for the site. Contaminant sources, routes of exposure, and receptors are evaluated to determine the relative threats posed by each source within the project boundary and each exposure pathway.

SECTION 6.0: RECLAMATION OBJECTIVES AND GOALS: Presents the reclamation objectives and applicable clean-up goals.

SECTION 7.0: DEVELOPMENT AND SCREENING OF RECLAMATION ALTERNATIVES: Identifies and screens potentially applicable reclamation alternatives. Reclamation alternatives are preliminarily evaluated based on effectiveness, implementability, and cost.

SECTION 8.0: DETAILED ANALYSIS OF RECLAMATION ALTERNATIVES: Presents the detailed analysis of reclamation alternatives pertaining to the seven NCP evaluation criteria. Only those alternatives that passed the initial evaluation presented in Section 7.0 are evaluated in this section.

SECTION 9.0: COMPARATIVE ANALYSIS OF RECLAMATION ALTERNATIVES: Presents a comparative analysis of the reclamation alternatives consistent with the NCP.

SECTION 10.0: PREFERRED ALTERNATIVE: Presents the recommended preferred alternative applicable to the Snowshoe Mine Site and summarizes the reasoning behind choosing this alternative.

SECTION 11.0: REFERENCES: Lists the references cited in the text.

2.0 SITE BACKGROUND

2.1 MINING HISTORY

The Snowshoe Mine was discovered in the late 1880s with claims established in 1889. Mining first began in 1892 with more extensive mining and smelting for lead, silver, and gold beginning in 1900. Between 1900 and 1912, approximately 225 tons of ore were treated in a nearby concentrating plant. In 1940, a portable selective flotation concentrator was installed on-site to mill the developed ore, mine dumps, and tailings. Prior to 1958, a 100-ton flotation mill was erected.

The mine employed up to 250 workers at one time and changed owners many times over the years; however, the property has been inactive since 1964. Over 11,000 feet of workings were excavated at the site including adits, shafts, and raises with total production estimated at 145,000 tons of ore valued at $1,211,000.00. The current owners of the claims were not involved in the past mining activities and have no plans to re-open the mine.

2.2 SITE SETTING

The Snowshoe Mine Site is accessed by traveling south on Highway 2 from Libby, Montana, and then turning right onto Bear Creek Road (FR 278), an improved gravel road. Approximately 3 miles from Highway 2, FR 867 veers to the southwest until meeting the intersection with FR 6213, approximately 5 miles from FR 278. The Snowshoe Mine Site is located approximately 3 miles from the intersection with FR 867.

The site lies within the Kootenai National Forest and is adjacent to the Cabinet Mountain Wilderness area. Elevation at the Snowshoe Mine Site ranges from approximately 4,560 to 5,600 feet above mean sea level. The terrain consists of steep mountainous slopes at the head of a glacial valley bisected by Snowshoe Creek. The valley floor is narrow and is essentially confined by steeply rising rock slopes. The legal description of the Snowshoe Mine Site is the Northwest Quadrant, Section 7 of Township 28 North, Range 31 West and covers approximately 9 acres. The site consists of four separate waste rock dumps and a mill tailings deposit located directly in the floodplain of Snowshoe Creek.

2.2.1 Vegetation and Wildlife

The Snowshoe Mine workings are located on a timbered sub-alpine slope with the tailings located directly in the floodplain of Snowshoe Creek. Regional and local vegetation consists of white bark pine, lodge pole pine, Douglas fir, birch, spruce, buffalo grass, and willows. There are no noxious weeds found at the site. Riparian plant communities occur in the study area associated with the Snowshoe Creek floodplain. In general, the area is continuously forested and is important habitat for a variety of big game animals, fur bearers, and birds.

The lynx (endangered species) and the grizzly bear (threatened species) can be found in the Snowshoe Mine Site area. Two species of moss, listed as "Species of Concern," have been identified in the Snowshoe Creek drainage and an adjacent drainage. Appendix B contains the plant and animal species list for the site as identified in the *Montana Natural Heritage Program Threatened and Endangered Species Report, Snowshoe Mine Site* (Montana Natural Heritage Program, 2001).

2.2.2 Historic or Archaeologically Significant Features

A cultural resource study was completed for the Snowshoe Mine in 1985 by Paul Anderson entitled, "*A Cultural Resource Study of Selected Mining District and Mine Sites in Western Montana*." According to the Anderson report, the site consisted of several standing structures, adits, waste rock piles and debris associated with mining activity. Seven open adits are located on the south side of Snowshoe Creek. These were placed at intervals on the hillside adjacent to an unnamed drainage. The report indicated all original structures were covered by waste rock and the concentrator complex was burned. The remaining structures dated from the 1940s, indicating they were less than 50 years old. The site was not recommended as being eligible for listing on the National Register of Historic Places.

In June 2001, Dale M. Gray (Frontier Historical Consultants) conducted the *Snowshoe Mine and Mill Cultural Inventory Assessment.* Gray concurred that the site has lost virtually all physical integrity both as an individual site and as a historic landscape. The site has been subject to natural forces such as decay, erosion, deposition and collapse. In addition, modern mining activities and reclamation work conducted in 1988-1989 have destroyed almost all of the site's historic features. The site is not recommended for listing on National Register of Historic Places under any criterion, nor is it recommended to be eligible as a historic mining landscape.

2.2.3 Land Use and Population

Existing use of the land surrounding the Snowshoe Mine Site is recreational and wildlife habitat. There are no permanent residents located within a one-mile radius of the site.

2.2.4 Climate

Like most of northwest Montana, the area is subject to a cool and dry, continental-dominated climate as stated in *NOAA Atlas 2-Precipitation-Frequency Atlas of the Western United States, Volume I-Montana* (NOAA, 1995). The region's temperature is generally low and marked by wide seasonal and daily variations. During winter, the temperature often drops to 32 degrees Fahrenheit (^{o}F) with extended periods of temperatures lower than 20 ^{o}F below zero. During summer, the days are generally warm, but temperatures decrease rapidly at nightfall. Precipitation is relatively abundant in the region (averaging approximately 18 inches annually), with most of the annual precipitation falling as snow during winter (55 inches average annual snowfall). Stormy weather usually brings the first snows during September; however, these storms are generally succeeded by several weeks of fair weather. By November, the area is usually covered with snow. Heavy snows are frequent in the winter, as are periods of melting and refreezing in spring. The snow pack generally remains in the area for seven months or longer, with spring thaw occurring in May or June. The area is subject to a distinct spring/summer rainy season with May and June each receiving 1.4 to 1.6 inches of precipitation annually, on average.

2.2.5 Geology

2.2.5.1 Regional Geologic Setting

The Snowshoe Mine Site is underlain by the Snowshoe fault. The east side of the fault consists of argillite and quartzite of the Precambrian Ravalli Group. The west side of the fault consists of shale and limestone of the Precambrian Wallace Formation as stated in the *Final Reclamation Work Plan for the Snowshoe Mine Site* (DEQ/MWCB-Pioneer, 2001).

2.2.5.2 Local Geologic Setting

The ore material at the Snowshoe Mine site occurs in the fissured and sheared zone of the Snowshoe fault. The shear zone attains a maximum width of 12 feet, but averages less than 6 feet wide. The shear zone has numerous quartz veins, varying between a fraction of an inch to approximately one foot wide. These veins contain carbonate and sulfides. The most abundant sulfides are silver-bearing galena and sphalerite, with less abundant pyrite, and traces of chalcopyrite and arsenopyrite. Gangue minerals include quartz, siderite, carbonate rock, and clay (DEQ/MWCB-Pioneer, 2001).

2.2.6 Hydrogeologic Setting

There is no published hydrogeologic information specific to the Snowshoe Mine Site. The conclusions regarding hydrogeologic conditions are, therefore, based on accepted hydrologic and geologic principals and local observations. The Snowshoe Mine Site is located within the Snowshoe Creek groundwater basin, which is part of the Big Cherry Creek groundwater basin.

The hydrogeologic system contains two components: the Precambrian metasedimentary bedrock and a thin veneer of Quaternary alluvium associated with Snowshoe Creek. The bedrock is highly fractured by the major displacement of the Snowshoe fault (estimated at more than 1,000 feet). This intense fracturing has likely resulted in a fairly permeable and transmissive bedrock aquifer system. The alluvial deposits are small, thin, and discontinuous and likely transmit both surface water from local streams and discharging bedrock groundwater. Alluvial groundwater is present in the area at a shallow depth, but is probably perched on carbonate hardpan. Bedrock groundwater is likely deep, as evidenced by a lack of continuous discharge from the several adits on the site (DEQ/MWCB-Pioneer, 2001).

2.2.7 Surface Water Hydrology

The site is located at the headwaters of Snowshoe Creek, approximately three miles above its confluence with Big Cherry Creek. Big Cherry Creek ultimately flows approximately 14 miles to its confluence with the Kootenai River. The upper waste rock dumps associated with the site are located within an intermittent drainage of Snowshoe Creek. The base of Waste Rock #4 (WR-4) and the mill tailings are located directly within the floodplain of Snowshoe Creek.

The U.S. Geological Survey (USGS) report, *Revised Techniques for Estimating Magnitudes and Frequency of Floods in Montana* (USGS Open-File Report 92-4048) was used to estimate the peak flood events for Snowshoe Creek. The Snowshoe Creek drainage is approximately 2.0 square miles of steeply forested ground. The following is a summary of the peak flow estimates for various return periods in the Snowshoe Creek drainage:

PEAK FLOW (cubic feet per second [cfs])

Return Period (years)	Snowshoe Creek (cfs)
2	27.4
5	43.9
10	57.9
25	72.8
50	87.5
100	99.6
500	134.0

3.0 WASTE CHARACTERISTICS AND SUMMARY OF EXISTING SITE DATA

3.1 PREVIOUS INVESTIGATIONS

Previous site reclamation work and site investigations performed at the Snowshoe Mine Site include the 1988-1989 Reclamation Project, the 1993 Hazardous Materials Inventory, the 2002 Mine Reclamation Investigation, the 2004 Repository/Borrow Area Investigation conducted by Pioneer, and the 2004 Repository/Borrow Area Investigation conducted by MAXIM. The following sections summarize activities and findings from these investigations.

3.1.1 1988-1989 Reclamation Project

During 1988 and 1989, reclamation work was initiated at the site. Response actions were conducted at the Snowshoe Mine Site by Mountain Construction from Helena, Montana. This work was administered by the Montana Department of State Lands (DSL). According to the 1989 report, *Final Close-Out Report Snowshoe Creek Streambank Reclamation Project* (Delta Engineering, 1989), submitted to the DEQ/MWCB, the tailings material and wooden debris were removed to an on-site disposal area and graded to form positive drainage. The disposal area was constructed out of the floodplain and physically and hydraulically isolated from any active or ephemeral drainages.

An excavator was used to excavate the tailings material immediately adjacent to the streambank. A loader equipped with a brush fork was used to handle and transport the extensive wooden debris and stumps to the disposal area where they were buried. The tailings disposal area and the former tailings deposition areas were neutralized with the recommended application rate of lime ($CaCO_3$). The lime was spread on the flatter areas with a fertilizer spreader and a manure spreader. The fertilizer spreader was not effective because the maximum rate of feed was one ton per acre. The manure spreader worked well and provided a consistent and efficient means of applying the lime. The lime was spread by hand on several areas that were too steep for the spreading equipment. The lime was incorporated and mixed using an agricultural disc and a dozer equipped with a ripper.

The open mine adit had a drain installed that was sealed and backfilled with native soil. The drain was extended to the edge of the creek to eliminate any overland flow of the undiluted acid mine drainage. The discharge was not sealed off during the project for safety reasons; the backup could have created dangerous hydraulic pressures within the mine. There is no proven technology available to passively treat the acid mine drainage in this sort of environment. By piping the acid mine drainage to the creek, additional contamination resulting from the acidic water running over and through the tailings area was eliminated.

Topsoil was applied to the waste disposal area at the prescribed depth of six inches. Topsoil was hauled to the site from an off-site borrow area provided by the U. S. Department of Agriculture/U.S. Forest Service (USFS). The USFS had several areas where they were excavating "Moose Pits" to improve habitat for the local moose population. Using the pit material for topsoil at the Snowshoe Mine Site was beneficial to both the USFS and the reclamation project. The USFS hired Mountain Construction to haul additional topsoil to the floodplain area of the project that was not originally specified to receive topsoil.

Fertilizer and seed were applied to all of the disturbed areas via broadcasting equipment including the steep or inaccessible areas. The disposal area was mulched with wood fiber mulch applied at a rate of 2,500 pounds per acre. A tackifier was also used with the mulch at a rate of 40 pounds per acre. The main road to the site was left open as the USFS requested, but all other roads within the site were reclaimed.

3.1.2 1993 Hazardous Material Inventory

In August 1993, the DEQ/MWCB conducted an investigation at the Snowshoe Mine Site as part of the *Montana Department of State Lands, Abandoned Mine Reclamation Bureau Hazardous Materials Inventory, Snowshoe Mine Site* (DEQ/MWCB-Pioneer, 1993). Surface water samples, stream sediment samples, and soil/source samples were collected and analyzed for several constituents and parameters. Figure 3-1 depicts existing features associated with the site as well as sample locations from the 1993 investigation. The 1993 Hazardous Material Inventory analytical data for soil sampling, water quality sampling, and sediment sampling is provided in Appendix A1. Table A1-1 provides total metals results for soil and sediment samples, Table A1-2 provides Acid-Base Accounting (ABA) results, Table A1-3 provides water quality data, and Table A1-4 provides wet chemistry and field measurements.

During the Hazardous Material Inventory at the Snowshoe Mine Site, three waste types of concern were identified including: four uncontained waste rock dumps, mill tailings deposits located in the floodplain, and a polyvinyl chloride (PVC) pipe which intermittently drains one of the adits which then discharges directly to Snowshoe Creek. Waste sources were identified as Tailings Pile (TP)-1 (south side of Snowshoe Creek) and TP-2 (north side of Snowshoe Creek), WR-1, WR-2, WR-3, and WR-4.

According to the inventory, TP-1 and TP-2 appear to be causing the majority of the sedimentation and water quality problems in Snowshoe Creek. The lower waste rock dump, WR-4, is another primary source of potential surface water contamination. The upper waste rock dumps, WR-1, WR-2, and WR-3 and the pipe discharge (SW-3) do not appear to be significant sources of sedimentation or metals loading to Snowshoe Creek, although all the dumps are located in an intermittent drainage, providing a direct runoff pathway to Snowshoe Creek during wet periods.

There were 6 adits identified during the 1993 inventory, 3 collapsed and 3 open. The adits are located along an unnamed tributary that in 1993 had only a trickle of water flowing in the tributary. During the 2002 investigation, there was no running water observed in this tributary.

3.1.2.1 <u>Solid Media Sampling Results</u>

Results of 1993 sampling of the waste sources (Figure 3-1) indicated that arsenic, cadmium, iron, lead, manganese, and zinc levels were elevated in the tailings at least three times the concentrations detected in the background soil samples (Table A1-1, Appendix A1). The 1993 sampling also indicated that arsenic, cadmium, copper, iron, lead, manganese, and zinc levels were elevated in the waste rock dumps at least three times the concentrations detected in background soil samples. The ABA testing indicates that waste sources are potentially acid producing (Table A1-2, Appendix A1).

3.1.2.2 Stream Sediment and Surface Water Sampling Results

During the 1993 inventory, Pioneer collected two-paired surface water and stream sediment samples from Snowshoe Creek as well as one water sample from a PVC pipe discharging from beneath WR-4 (the PVC pipe is no longer present). Sediment samples (27-005-SE1 and 27-005-SE2) collected upstream and downstream, respectively, in Snowshoe Creek indicated that numerous metal contaminants are entering the surface water system as suspended sediments from the physical transport of fine-grained mineralized waste rock/tailings (via erosion and runoff). The concentrations of arsenic, cadmium, manganese, lead and zinc are significantly elevated (>3 times) in the downstream sediment sample when compared to the upstream sediment sample. Additionally, the Maximum Contaminant Levels (MCLs) for cadmium and lead were exceeded in the downstream surface water sample, as were the acute and chronic aquatic life criteria for lead as listed in the *Montana Department of Environmental Quality, Water Quality Bureau Circular 7 [WQB-7]* (DEQ/WQB, 2002). These exceedances were all directly attributable to the site.

The surface water sample collected upstream (27-005-SW1) from the mine site exhibits contaminant levels at or below detection values with only slightly elevated levels of barium and copper. The downstream sample (27-005-SW2) exhibits contaminant levels at or below detection levels with the exception of barium and cadmium. The sample collected from the PVC pipe at WR-4 (27-005-SW3) exhibits elevated levels of barium, cadmium, and copper.

The groundwater at the Snowshoe Mine Site is not currently used as a drinking water source, nor is it likely to be. However, there is a groundwater monitoring well installed in the floodplain of the site. The exact date and purpose of installation is unknown. Figure 3-1 provides the locations for the paired stream/sediment samples collected in 1993 and Tables A1-3 and A1-4 in Appendix A1 summarize the analytical results.

3.1.3 2002 Mine Reclamation Investigation

The objective of the 2002 Snowshoe Mine Site Reclamation Investigation was to evaluate the mine and mill wastes at the site while generating a database that meets the requirements necessary to complete a risk assessment and detailed analysis of reclamation alternatives. The following sections discuss each individual Snowshoe Mine Site waste source investigated by Pioneer in 2002.

3.1.3.1 Mine Waste Sources

Waste sources at the Snowshoe Mine Site reside on three patented mining claims and lands administered by the Kootenai National Forest. Table 3-1 identifies each claim, the associated mineral number, and which waste sources are situated on the particular claim. Figure 1-3 illustrates claim boundaries and waste sources at the site.

TABLE 3-1
PROPERTY OWNERSHIP
SNOWSHOE MINE SITE

WASTE SOURCE	CLAIM NAME	MINERAL SURVEY No.	% PRIVATE OWNERSHIP
WR-1	Snowshoe	5316	100%
WR-2	Rustler	5315	100%
WR-3	Rustler	5315	100%
WR-4	Rustler	5315	100%
Tailings (TP-1)	Chinook	5278	83%

3.1.3.1.1 Waste Rock Dump #1 (WR-1)

Waste Rock Dump #1 (WR-1) is a fairly large dump located near the head of a small ephemeral drainage on the Snowshoe Mining Claim, near the top of the ridge (Figure 1-2). WR-1 encompasses approximately 0.35 acres with an estimated volume of approximately 2,500 cubic yards. This dump is not traditionally shaped, but is fan shaped from snow and water erosion. There is a small open adit associated with this waste rock dump.

Due to the inaccessibility of WR-1, no test pits were completed. One surface grab sample was collected and analyzed for metals, ABA, agronomic and physical parameters. Concentrations of the following metals are significantly elevated above background (>3 times) in the dump: antimony, arsenic, cadmium, copper, iron, mercury, lead, silver, and zinc (Appendix A2, Table A2-2).

Agronomic data and ABA (Tables A2-3 and A2-5, Appendix A2) were obtained for the waste rock dump for reclamation scenarios involving stabilization and revegetating in-place. The ABA and SMP buffering capacity results indicate that WR-1 is not considered a potential acid producer. Organic amendment of the dump material is advised due to the moderate organic matter content (3.2%). In addition to providing temporary stabilization of the disturbed erodible surfaces, application of wheat or barley straw mulch would assist in providing necessary organic material to help promote successful revegetation.

Fertilizer recommendation analyses provided the following results for WR-1: 40 pounds nitrogen required per acre; 35 pounds phosphate per acre; and 35 pounds potassium required per acre (Table A2-5, Appendix A2). The breakdown of the revegetation requirements as presented should be considered preliminary at this time (for planning purposes only). If the waste rock is revegetated in-place, it will be re-sampled and the results will be reevaluated after construction activities have been implemented and WR-1 has been recontoured and prepared for vegetation. As shown in Appendix A2-6 (Appendix A2), the waste rock soil is generally sandy loam in texture.

3.1.3.1.2 Waste Rock Dump #2 (WR-2)

Waste Rock Dump #2 (WR-2) is a moderately sized dump located at the toe of WR-1 and slightly to the east on the Rustler Mining Claim (Figure 1-2). WR-2 encompasses approximately 0.1 acre with an estimated volume of approximately 450 cubic yards. There is a large open adit located directly above the dump materials. During the July 2002 site investigation, recreationalists were observed entering the adit.

Due to the inaccessibility of WR-2, no test pits were completed. One surface grab sample was collected and analyzed for metals, ABA, agronomic and physical parameters. Concentrations of the following metals are significantly elevated above background (>3 times) in the dump: antimony, cadmium, copper, lead, mercury, silver, and zinc (Appendix A2, Table A2-2). Agronomic and ABA data were obtained for the waste rock dump for reclamation scenarios involving stabilization and revegetating in-place. The ABA and SMP buffering capacity results (Table A2-3, Appendix A2) indicate that WR-2 is considered a potential acid producer and up to 233 tons of lime per acre would be required to successfully establish vegetation on this material, assuming a 12-inch depth of incorporation. Organic amendment of the dump material is advised due to the moderate organic matter content (3.6%). In addition to providing temporary stabilization of the disturbed erodible surfaces, application of wheat or barley straw mulch would assist in providing necessary organic material to help promote successful revegetation.

Fertilizer recommendation analyses provided the following results for WR-2: 40 pounds nitrogen required per acre; 40 pounds phosphate per acre; and 35 pounds potassium required per acre (Table A2-5, Appendix A2). The breakdown of the revegetation requirements as presented should be considered preliminary at this time (for planning purposes only). If the waste rock is revegetated in-place, it will be re-sampled and the results will be re-evaluated after construction activities have been implemented and the WR-2 has been recontoured and prepared for vegetation. As shown in Table A2-6 (Appendix A2), the waste rock soil is generally sandy loam in texture.

3.1.3.1.3 Waste Rock Dump #3 (WR-3)

Waste Rock Dump #3 (WR-3) is a small dump located on the west side of the ephemeral drainage, below WR-1 and WR-2 on the Rustler Mining Claim (Figure 1-2). WR-3 encompasses approximately 0.05 acre with an estimated volume of approximately 200 cubic yards.

Due to the inaccessibility of WR-3, no test pits were completed. One surface grab sample was collected and analyzed for metals, ABA, agronomic and physical parameters. Concentrations of the following metals are significantly elevated above background (>3 times) in the dump: antimony, arsenic, copper, lead, silver, and zinc (Table A2-2, Appendix A2).

Agronomic and ABA data were obtained for the waste rock dump for reclamation scenarios involving stabilization and revegetating in-place. The ABA and SMP buffering capacity results (Table A2-3, Appendix A2) indicate that WR-3 is considered a potential acid producer and up to 32 tons of lime per acre would be required to successfully establish vegetation on this material, assuming a 12-inch depth of incorporation. Organic amendment of the dump material is advised due to the relatively low organic matter content (1.6%). In addition to providing temporary stabilization of the disturbed erodible surfaces, application of wheat or barley straw mulch would assist in providing necessary organic material to help promote successful revegetation.

Fertilizer recommendation analyses provided the following results for WR-3: 40 pounds nitrogen required per acre; 35 pounds phosphate required per acre; and 35 pounds potassium required per acre (Table A2-5, Appendix A2). The breakdown of the revegetation requirements as presented above, should be considered preliminary at this time (for planning purposes only). If the waste rock is revegetated in-place, it will be re-sampled and the results will be reevaluated after construction activities have been implemented and the dump has been recontoured and prepared for vegetation. As shown in Table A2-6 (Appendix A2), the waste rock soil is generally sandy loam in texture.

3.1.3.1.4 Waste Rock Dump #4 (WR-4)

Waste Rock Dump #4 (WR-4) is the largest waste rock dump at the site and is located near the mouth of the ephemeral drainage where it discharges into Snowshoe Creek on the Rustler Mining Claim (Figure 1-2). WR-4 was used as a consolidation area during previous reclamation activities at the site. The soil cap is showing signs of failure with several areas devoid of vegetation with erosion rills and gullies forming. The PVC pipe used to drain Adit #6 is completely destroyed from erosion and other disturbances (snow slides). The storm water channel located along the east side of the dump has failed with a majority of the riprap having been eroded downgradient and portions of filter fabric exposed and torn. There is a narrow strip of exposed mine waste along the north face of the dump that is contributing sediment to Snowshoe Creek. WR-4 encompasses approximately 2.3 acres with an estimated volume of approximately 33,710 cubic yards.

Eight test pits were excavated through the waste rock using an excavator. Three composite samples were collected, including one surface soil sample (WR4-1A) and two subsurface samples (WR4-1B and WR4-8B), and analyzed for metals, ABA, Toxicity Characteristic Leaching Procedure (TCLP) Metals, and agronomic and physical parameters. Concentrations of the following metals are significantly elevated above background (>3 times) in WR-4: antimony, arsenic, cadmium, copper, lead, silver, and zinc (Table A2-2, Appendix A2). Additionally, cadmium and lead exceed TCLP Metals criteria (Table A2-4, Appendix A2).

Agronomic and ABA data were obtained for the waste rock dump for reclamation scenarios involving stabilization and revegetating in-place. The ABA and SMP buffering capacity results (Table A2-3, Appendix A2) indicate that WR-4 is considered a potential acid producer and up to 237 tons of lime per acre would be required to successfully establish vegetation on this material, assuming a 12-inch depth of incorporation. Organic amendment of the dump material is advised due to the relatively low organic matter content (1.9 to 3.3%). In addition to providing temporary stabilization of the disturbed erodible surfaces, application of wheat or barley straw mulch would assist in providing necessary organic material to help promote successful revegetation.

Fertilizer recommendation analyses provided the following results for WR-4: 45 pounds nitrogen required per acre; 40 pounds phosphate required per acre; and 35 pounds potassium required per acre (Table A2-5, Appendix A2). The breakdown of the revegetation requirements as presented above, should be considered preliminary at this time (for planning purposes only). If the waste rock is revegetated in-place, it will be re-sampled and the results will be re-evaluated after construction activities have been implemented and the dump has been recontoured and prepared for vegetation. As shown in Table A2-6 (Appendix A2), the waste rock is generally sandy loam in texture.

3.1.3.1.5 Floodplains Tailings

The tailings are currently located directly within the floodplain of Snowshoe Creek and directly downstream of WR-4 on the Chinook Mining Claim (Figure 1-2). During the site investigation, tailings and mine waste were observed within the active portion of the stream channel on both the north and south sides of the creek. The uncontained tailings encompass approximately 7.3 acres with an estimated volume of 85,300 cubic yards. Of this estimated volume, approximately 5.8 acres and 70,785 cubic yards are located on the Chinook mining claim (private). The remaining tailings, approximately 14,525 cubic yards, encompass approximately 1.5 acres and are located on Kootenai National Forest lands. No test pits were completed on USFS lands; the volume estimate is based on visual observations and test pits completed near the Chinook mining claim boundary and USFS lands.

Seventeen test pits were completed on the south side of Snowshoe Creek (TP-1), and an additional 6 test pits were completed on the north side (TP-2) of Snowshoe Creek. Appendix A2 presents a summary of sampling (Table A2-1), analytical data for metals (Table A2-2), ABA data (Table A2-3), TCLP Metals (Table A2-4), agronomic data (Table A2-5), and physical parameters (Table A2-6). Each tailings area is discussed separately in the following sections.

<u>TP-1, South Side of Snowshoe Creek</u>

As stated previously, 17 test pits were completed along the south side of Snowshoe Creek. From these test pits, 4 composite samples were collected; TP1-1A surface composite sample, and TP1-1B, TP1-8B, and TP1-12B were composited subsurface samples and analyzed for metals, ABA, TCLP Metals, and agronomic and physical parameters. Concentrations of the following metals are significantly elevated above background (>3 times) in TP-1: antimony, arsenic, cadmium, lead, and zinc (Appendix A2, Table A2-2). Additionally, lead exceeds TCLP Metals criteria (Appendix A2, Table A2-4).

Agronomic and ABA data were obtained for the reclamation scenarios involving stabilization and revegetating the tailings in-place. The ABA and SMP buffering capacity results (Table A2-3, Appendix A2) indicate that TP-1 is considered a potential acid producer and up to 47 tons of lime per acre would be required to successfully establish vegetation on this material, assuming a 12-inch depth of incorporation. Organic amendment of the tailings material is advised due to the relatively low organic matter content (0.2 to 2.9%). In addition to providing temporary stabilization of the disturbed erodible surfaces, application of wheat or barley straw mulch would assist in providing necessary organic material to help promote successful revegetation.

Fertilizer recommendation analyses provided the following results for TP-1: 40 pounds nitrogen required per acre; 45 pounds phosphate required per acre; and 35 pounds potassium required per acre (Table A2-5, Appendix A2). The breakdown of the revegetation requirements as presented should be considered preliminary at this time (for planning purposes only). If the tailings materials are revegetated in-place, the area will be re-sampled and the results will be reevaluated after construction activities have been implemented and the materials has been stabilized and prepared for vegetation. As shown on Table A2-6 (Appendix A2), the tailings are generally sandy loam/silty loam in texture.

TP-2, North Side of Snowshoe Creek

As stated previously, 6 test pits were completed along the north side of Snowshoe Creek (Figure 1-2). From these test pits, 1 composite subsurface sample was collected (TP2-4B). The sample was analyzed for metals, ABA, TCLP Metals, and agronomic and physical parameters. No metal concentrations were significantly elevated above background (>3 times) (Table A2-2, Appendix A2) and no metals exceeded TCLP criteria (Table A2-4, Appendix A2).

The ABA and agronomic data were obtained for the reclamation scenarios involving stabilization and revegetating the tailings in-place. The ABA and SMP buffering capacity results (Table A2-3, Appendix A2) indicate that TP-2 is considered a potential acid producer and up to 13 tons of lime per acre would be required to successfully establish vegetation on this material, assuming a 12-inch depth of incorporation. Organic amendment of the tailings material is advised due to the relatively low organic matter content (2.0%). In addition to providing temporary stabilization of the disturbed erodible surfaces, application of wheat or barley straw mulch would assist in providing necessary organic material to help promote successful revegetation.

Fertilizer recommendation analyses provided the following results for TP-2: 40 pounds nitrogen required per acre; 25 pounds phosphate required per acre; and 35 pounds potassium required per acre (Table A2-5, Appendix A2). The breakdown of the revegetation requirements as presented should be considered preliminary at this time (for planning purposes only). If the tailings materials are revegetated in-place, the area will be re-sampled and the results will be reevaluated after construction activities have been implemented and the materials have been stabilized, rough graded, and prepared for vegetation. As shown in Table A2-6 (Appendix A2), the tailings are generally silty loam in texture.

3.1.3.2 2002 Reclamation Investigation Source Sampling Summary

The 2002 Reclamation Investigation included collecting solid media samples from the identified waste sources (Table A2-1, Appendix A2). Target Analyte List (TAL) metals included analyses following the Contact Laboratory Program (CLP) methods for determining the concentrations of the following elements: arsenic, barium, cadmium, cobalt, chromium, copper, iron, mercury, manganese, nickel, lead, antimony, silver, and zinc. Laboratory analyses for the TAL were all performed at the HKM Laboratory in Butte, Montana.

The ABA analyses including determination of sulfur fractions and neutralization potential were performed as were hazardous waste characteristics as by determined by TCLP metals analyses. All analyses were all performed at the HKM Laboratory in Butte, Montana. The analytical data from the 2002 Reclamation Investigation for all solid media including stream sediment samples are provided in Appendix A2. Table A2-1 contains a summary of soil, sediment, and borrow area sampling, Table A2-2 contains TAL results, Table A2-3 contains ABA results, Table A2-4 contains TCLP Metals results, Table A2-5 contains Agronomic data, and Table A2-6 contains physical chemistry results. Figure 3-2 depicts the location of each sample location.

The principal techniques used for data acquisition during the 2002 investigation included excavation of multiple test pits (excavator and shovel), detailed topographic mapping, and soil and water sampling. Samples were collected using standard operating procedures (SOPs) that are contained in the *Field Sampling Plan* (FSP) and were analyzed according to the *Laboratory Analytical Protocol* (LAP). The FSP and LAP are included in the *Final Reclamation Work Plan for the Snowshoe Mine Site* (DEQ/MWCB-Pioneer 2001). Analytical data compiled during this investigation were evaluated in accordance with the *Quality Assurance Project Plan* (QAPjP) contained in the *Final Reclamation Work Plan for the Snowshoe Mine Site (*DEQ/MWCB-Pioneer 2001). Results of the 2002 Reclamation Investigation are documented in the *Final Reclamation Investigation Report for the Snowshoe Mine Site* (DEQ/MWCB-Pioneer, 2004a).

3.1.3.3 Background Soil

Six background soil samples were collected at the Snowshoe Mine Site, one in 1993 (sample 27-005-BG-1) and five in 2002 (samples BG-1, BG-2, BG-3, BG-4, and BG-5). The background samples consisted of surface soil composite samples. Background sample BG-4 exhibited elevated concentrations of arsenic, cadmium, copper, lead, and zinc. This sample was collected north of the tailings floodplain within a vegetated area. It is assumed that the elevated metal concentrations are from past wind blown dust particles from the tailings. Due to elevated metals concentrations in this sample, it was not used as a basis for comparing waste source metal concentrations to background metal concentrations.

3.1.3.4 Stream Sediment and Surface Water Sampling Results

On July 29, 2002, Pioneer collected 8 paired surface water and stream sediment samples and 1 surface water sample from a seep on WR-4, (near Adit #6) as part of the Reclamation Investigation (Figure 3-3).

Surface water samples collected at the site were analyzed for the following elements: arsenic, barium, cadmium, calcium, cobalt, chromium, copper, iron, magnesium, mercury, manganese, nickel, lead, antimony, silver, and zinc. In addition, wet chemistry parameters (total dissolved solids [TDS], chloride, sulfate, nitrate-nitrite, and hardness) were analyzed as were field parameters (pH, specific conductivity [SC], alkalinity, and temperature).

One sample location from the 1993 Investigation (SW-1/SE-1) and 1 sample location from the 2002 Investigation (SW-1/SE-1) are both located upstream of all mine waste sources, including the tailings. Water quality data indicate that Snowshoe Creek is being impacted by mine/mill wastes. Surface water samples collected downstream of the mine waste sources were generally of poor quality. Exceedances of water quality standards at each Snowshoe Creek station are summarized in Table 3-2.

TABLE 3-2
SURFACE WATER QUALITY STANDARD EXCEEDANCES
SNOWSHOE MINE SITE

LOCATION	Cd	Cu	Pb	Zn
SW-01 upstream of site	--	--	--	--
SW-04 below WR-4	CAL	CAL	CAL	--
SW-05 within tailings	CAL, AAL	--	CAL	CAL, AAL
SW-02 below tailings	CAL, AAL	--	CAL	CAL, AAL
SW-07 downstream of site	CAL, AAL, HHS, MCL	--	CAL, AAL, HHS	CAL, AAL

CAL= Chronic aquatic life standard (WQB-7)
AAL= Acute aquatic life standard (WQB-7)
HHS= Montana Human Health Standard (WQB-7)
MCL= Safe Drinking Water Act Maximum Contaminant Level

Nine stream sediment samples were collected in July 2002 at the same locations as surface water samples (Figure 3-3). Stream sediment samples were analyzed for the same multi-element suite of total metals as the soil samples. Metal concentrations in stream sediments may be source related, with solid phase metals released from the wastes during runoff events and dissolved metals from groundwater inflow precipitating to sediment during base flow. Sediment sample SE1 collected upstream of the mine site indicates several elevated metal concentrations when compared to background sediment sample collected in 1993. Therefore, the sediment sample results for 27-005-SE1 collected in 2002 are not used for comparison purposes. Sediment samples are compared to 27-005-SE1 collected in 1993. Comparing downstream sediment samples collected in 2002 to the background sediment sample collected in 1993 indicates that the following metals: antimony, arsenic, cadmium, copper, iron, mercury, lead and zinc were higher (>3 times) in downstream samples compared to the upstream sediment sample.

A concentration analysis was performed using the 2002 data in an attempt to identify contributions to surface water and sediment from specific sources present at the site. Significant increases of contaminants between stations can indicate contaminant sources to Snowshoe Creek. The result of this analysis is presented in Table 3-3.

TABLE 3-3
SIGNIFICANT SURFACE WATER AND SEDIMENT CONCENTRATION INCREASES
SNOWSHOE MINE SITE

STREAM REACH	SOURCES WITHIN REACH	INCREASED CONTAMINANTS IN SURFACE WATER	INCREASED CONTAMINANTS IN STREAM SEDIMENT
SW1 to SW4	WR-4 and upper waste rock dumps	Cd, Pb, Zn, pH	
SW4 to SW2	floodplain tailings	Cd, Pb, Zn, -Alkalinity, -pH	Sb, As, Cd, Cu, Fe, Pb, Mn, Hg, Ag,
SW2 to SW7*	None	As, Cd, Pb, Mn, Zn, pH, Alkalinity	Cu, Mn, Pb

- = concentration decreased from previous station
SW7* = is located approximately 0.25 mile downstream from the mine site

Elevated metals concentrations in surface water appear to be related to both the waste rock and the tailings within the floodplain via surface seeps and groundwater discharges. The decreases in pH and alkalinity between Stations SW-4 and SW-2 indicate possible acid generation within the floodplain tailings and subsequent release to surface water. Metal concentrations in stream sediments appear to be related to the floodplain tailings and in-stream sediment movement. The increase of metals in sediment below the site may be related to precipitation as pH and alkalinity increase downstream.

All surface water and sediment sample analytical data are provided in Appendix A2. Table A2-7 contains TAL results for surface water and groundwater samples and Table A2-8 contains wet chemistry results.

3.1.3.5 <u>Groundwater Sampling Results</u>

One groundwater monitoring well is located on the eastern side of the site within the tailings and Snowshoe Creek floodplain (Figure 3-3). This well was not present during the 1993 investigation. During the July 2002 investigation, one sample (GW-3) was collected from this well and analyzed for dissolved metals (same metals as surface water samples), TDS, chloride, nitrates, sulfate, and hardness. Field parameters included pH, alkalinity, temperature, and SC. The groundwater analytical results are presented in Table A2-7 with field parameter data presented in Table A2-8 (Appendix A2).

Elements that are elevated in the groundwater that exceed the Human Health Standards (HHSs) as listed in the *Montana Department of Environmental Quality, Water Quality Bureau Circular 7 [WQB-7]* (DEQ/WQB, 2002) include: antimony, arsenic, cadmium, iron, lead, manganese, and zinc.

3.1.4 Repository/Borrow Area Investigations

Three separate investigations focusing on identifying areas near the Snowshoe Mine Site that could potentially supply adequate vegetative cover soil and/or serve as a potential repository site were completed in 2002 and 2004. Figure 3-2 and Figure 3-4 depict the locations of these sites.

3.1.4.1 2002 Borrow Area Investigation - Pioneer

During the 2002 Reclamation Investigation, Pioneer excavated 15 test pits along the timbered southern edge of the tailings (Figure 3-2). The test pits were excavated within the Chinook mining claim boundary. Test pits were excavated as far back into the timber as possible. Groundwater was encountered in 4 of the 15 test pits (BA1-4, BA1-5, BA1-10, and BA1-12) at depths ranging from 5 to 9 feet below ground surface. Four composite samples were collected from the borrow area test pits for the following analyses: U.S. Department of Agriculture (USDA) texture; organic matter content; pH; SC; total metals; ABA; Cation Exchange Capacity (CEC); sodium adsorption ratio; saturation percentage; fertilizer recommendation; field capacity and wilting point. Analytical data from the 2002 Borrow Area Investigation are provided in Appendix A2. Table A2-1 provides a summary of samples collected including sample depths, Table A2-2 contains total metals results, Table A2-3 contains ABA data, Table A2-5 contains agronomic data, and Table A2-6 contains physical chemistry results.

The analytical results were used primarily to assess the revegetation characteristics of the material for use as cover soil. In general, test pit depths ranged from 3 to 13 feet, soil textures ranged from loam/sandy loam to silty loam and contained a relatively low to moderate organic matter content (0.5 to 6%); application of organic amendment would be advisable to increase fertility of the soil. The metals concentrations are comparable to the results of the background soil samples collected. Fertilizer recommendation analyses provided the following results: 45 pounds nitrogen required per acre; 35 pounds of phosphate required per acre; and 35 pounds potassium required per acre. The pH of the soil ranged from 4.59 to 5.69, which is moderately acidic, and conductivity of the soil is low (41.8 to 232 micromhos per centimeter [μmhos/cm]). The ABA analyses showed a positive ABA (32 to 39.3 tons/acre); therefore, lime amendment would be required. The sodium adsorption ratio of the soil is low, within the desired range, and the saturation percentage is moderately high, but still within the acceptable range. The CEC is 1.4 to 10.7 milliequivalents per 100 grams (meq./100g) which is low, indicating very little capacity to attenuate contaminants.

Although no large volume/bulk gradation analyses were conducted, visual evaluation of the soil indicated a relatively high percentage of oversized rock (four-inch plus material). In general, the rock content increased with depth. The rock content was visually estimated to range between 15 to 60%, with several test pits estimated at over 80% 12-inch plus rock. Consequently, if this location were used as a source of borrow soil, a four-inch or six-inch grizzly would be desirable to screen the excavated materials during construction to eliminate oversize reject rock and create higher quality cover soil. Roughly 60% of the excavated volume would be eliminated as reject oversize rock. In other words, to create the quantity of cover soil needed for the project, approximately 160% of the required cover soil volume would have to be excavated from Borrow Area 1.

3.1.4.2 2004 Repository/Borrow Area Investigation - Pioneer

Two potential mine waste disposal sites (Figure 3-4), identified by the USFS and located in relatively close proximity to the Snowshoe Mine Site, were investigated by Pioneer in July 2004 and documented in the *Draft Repository Investigation for the Snowshoe Mine Site* (DEQ/MWCB-Pioneer, 2004b). These potential repository sites were investigated because adequate borrow material was not identified during the 2002 investigation at the Snowshoe Mine Site. The 2004 investigation was initiated to determine whether adequate capacity is available to dispose of the mine wastes currently located at the Snowshoe Mine Site. Additionally, the sites were investigated to determine whether an adequate quantity and sufficient quality of cover soil is available to complete the planned reclamation at the site. According to preliminary calculations, the repository would be sized to occupy roughly 5 acres of land to contain 120,000 cubic yards of mine waste, and would be designed to generate a minimum of 32,000 cubic yards of cover soil to complete the reclamation project.

Repository Site A

Repository Site A (Site A) is located in a 70-acre (approximate) clear cut directly south of Leigh Creek and approximately 3 air miles east of the Snowshoe Mine Site (Figure 3-4). The legal description of the site is the northern half of Section 5, Township 28 North, Range 31 West. Average elevation at this site is approximately 3,440 feet above mean sea level (amsl). The average elevation at the Snowshoe Mine Site is approximately 4,500 feet amsl. According to USFS personnel, timber was harvested from this area during the 1980s. Timber re-growth throughout the entire clear cut is significant; the area is currently very heavily timbered. Access to Site A is straightforward. The site is reached by traveling southwest on USFS Route 278 to where the road crosses Leigh Creek via a new timber structure bridge. Approximately 500 feet beyond this Leigh Creek bridge, an unmarked dirt road branches off USFS Route 278 to the east and bisects the 70-acre clear cut. Site A is located near the eastern border of the clear cut.

Twelve test pits were excavated within the Site A study area on July 21, 2004 (Figure 3-5). The test pits encompassed an area of approximately 9 acres and ranged in depth from 5.0 to 10.5 feet below the ground surface. A small amount of groundwater was encountered in two of the test pits excavated within the northwestern section of the study area, near a small grove of Birch trees. It is unknown whether this small amount of groundwater is associated with a water table aquifer or represents an isolated area of perched water. However, considering that groundwater was only encountered in 2 of the 12 test pits, in a localized area of looser, sandier subsoils (compared to the heavily consolidated silts and clays found at depth in the remaining test pits), the water observed may represent an isolated zone of perched groundwater.

The test pit locations were selected at random and were excavated using a Caterpillar 205 track excavator. Table A3-1 (Appendix A3) indicates the total depth of each test pit and gives a brief description of the physical characteristics observed in each pit; Table A3-1 also lists the samples collected. The surface area available for repository construction within the clear cut is in the range of 30 to 50 acres of land administered by the USFS, Kootenai National Forest. The topography in the area is generally gently sloping (5% to 10% grade) with a northern aspect.

In general, the repository site consists of a relatively shallow layer of topsoil (6- to 12-inch depth) with abundant grass, low brush, roots, and relatively high organic matter content. The topsoil layer is underlain by several feet (5- to 10-feet thick) of tightly consolidated silt and clay with some gravel and cobbles. Rock content in the area is relatively low with the highest abundance of rock occurring in the northern half of the study area.

Two composite soil samples were collected from Site A for the following analyses: Total Metals; USDA texture; organic matter content; pH; SC; ABA; CEC; sodium adsorption ratio; saturation percentage; fertilizer recommendation; field capacity; and wilting point. Analytical results are provided in Tables A3-2, A3-3, A3-4 and A3-5 in Appendix A3.

The analytical results are used primarily to assess the revegetation characteristics of the material for use as cover soil. The results indicate that the subsoils are generally classified as clay loam and contain very low organic matter content (0.1 to 0.35%). Application of organic amendment would be advisable to increase the fertility of the soil for use as cover soil in the reclamation effort. Fertilizer recommendation analyses provided the following results: 50 pounds nitrogen required per acre; 30 pounds phosphate required per acre; and 40 pounds potassium required per acre.

The pH of the soil ranged from 5.4 to 5.8, which is moderately acidic (possibly the result of the thick conifer canopy in the area), and may warrant amendment with lime to neutralize the soil. Conductivity of the soil is very low (29.7 to 73.4 μmhos/cm), and metals concentrations are low as well (generally at or below background concentrations). The ABA analyses indicate that the soil has negligible neutralization potential and a minor amount of lime is recommended to neutralize the active acidity in the soil (approximately 5 to 6 tons of lime per acre is recommended, assuming a 1-foot depth of cover soil). The sodium adsorption ratio of the soil is favorably low (0.68 to 0.92), and the saturation percentage (33.9% to 34.3%) falls within the desired range of 25% to 85%. The CEC is low (4.0 to 5.6 meq./100g), indicating very little capacity of the soil to attenuate contaminants.

Repository Site B

Repository Site B (Site B) is located in a 30-acre (approximate) clear cut directly south of USFS Route 278 and north of Leigh Creek. The location is approximately 3¼ air miles east of the Snowshoe Mine Site and a quarter mile north of Site A (see Figure 3-4). The legal description of the site is the south-central boundary of Section 32, Township 29 North, Range 31 West and north-central boundary of Section 5, Township 28 North, Range 31 West. Average elevation at this site is approximately 3,400 feet amsl. According to USFS personnel, timber was harvested from this area during the late 1980s or early 1990s. Timber re-growth throughout most of the clear cut is significant; the majority of the area is fairly heavily timbered. The eastern third of the clear cut is currently very heavily timbered.

Access to Site B is via a road spur that branches to the west off USFS Route 278. The entrance to this road is currently blocked with a soil berm and the road is completely overgrown with brush and timber. Significant clearing would be required to make the road passable for equipment.

Fourteen test pits were excavated within the Site B study area on July 20, 2004 (Figure 3-6). The test pits encompassed an area of approximately 12 acres and ranged in depth from 8.0 to 13.0 feet below the ground surface. Groundwater was encountered in seven of the test pits; mostly within the northern and eastern portions of the site. It is unknown whether this groundwater is associated with a water table aquifer or represents an area of perched water. Several significant erosion gullies were observed within the clear cut. Additionally, a marshy area (approximately 1 acre in size) and small pond were identified in the southeastern portion of the clearcut. Based on visual evidence, this particular area appears to be subject to intense surface water runoff.

The test pit locations were selected at random and were excavated using a Caterpillar 205 track excavator. Table A3-1 (Appendix A3) indicates the total depth of each test pit and gives a brief description of the physical characteristics observed in each pit; Table A3-1 also lists the samples collected. The surface area available for repository construction within the clear cut is in the range of 6 to 7 acres of land administered by the USFS, Kootenai National Forest. The topography in the area is moderately sloping (15% to 20% grade) and variable with a south to southeastern aspect.

In general, Site B consists of a relatively shallow layer of topsoil (6- to 18-inch depth) with abundant grass, brush, roots, and relatively high organic matter content. The topsoil layer is underlain by several feet (5- to 10-feet thick) of sandy loam with abundant gravel and cobbles with boulders up to 12 inches in diameter. In general, higher quality soil is found along the eastern perimeter of the study area. The central and western sections contain soils with very high rock content; the rock content increasing with depth.

Although no large volume/bulk gradation analyses were conducted, the visual evaluation of the soil in the Site B area indicated a high percentage of oversize rock (2-inch plus material). Consequently, if Site B is selected, a 1-inch or 2-inch screen would be desirable to screen the excavated material during construction activities to eliminate reject oversize rock and create higher quality cover soil. Roughly 40% of the excavated volume is expected to be eliminated as reject oversize rock. In other words, to create the quantity of cover soil needed for reclamation of the Snowshoe Mine Site, up to approximately 140% of the required cover soil volume may need to be excavated from Site B.

Four composite soil samples were collected from Site B for the following analyses: total metals; USDA texture; organic matter content; pH; SC; ABA; CEC; sodium adsorption ratio; saturation percentage; fertilizer recommendation; field capacity; and wilting point. Analytical results are provided in Tables A3-2, A3-3, A3-4 and A3-5 in Appendix A3.

The analytical results are used primarily to assess the revegetation characteristics of the material for use as cover soil. The results indicate that the subsoils are generally classified as sandy loam and contain very low organic matter content (0.0 to 0.21%). Application of organic amendment would be advisable to increase the fertility of the soil for use as cover soil in the reclamation effort. Fertilizer recommendation analyses provided the following results: 50 pounds nitrogen required per acre; 20 pounds phosphate required per acre; and 40 pounds potassium required per acre.

The pH of the soil ranged from 5.4 to 5.6, which is moderately acidic (possibly the result of the thick conifer canopy in the area), and may warrant amendment with lime to neutralize the soil. Conductivity of the soil is very low (35.7 to 54.1 μmhos/cm), and metals concentrations are low as well (generally at or below background concentrations). The ABA analyses indicate that the soil has negligible neutralization potential and a minor amount of lime is recommended to neutralize the active acidity in the soil (approximately 3 to 5 tons of lime per acre is recommended assuming a 1-foot depth of cover soil). The sodium adsorption ratio of the soil is favorably low (0.91 to 1.00), and the saturation percentage (25.2% to 29.7%) falls within the desired range of 25% to 85%. The CEC is very low (1.7 to 2.0 meq./100g), indicating very little capacity of the soil to attenuate contaminants.

Summary and Conclusions

The 2004 field investigation of the two potential repository sites evaluated by Pioneer in 2004, confirmed that either site would likely be acceptable for disposal of mine wastes and for obtaining cover soil for the Snowshoe Mine Site. The only uncertainty associated with Site A and Site B involves the relatively shallow groundwater. Based on visual evidence, the groundwater at Site A appears to be an isolated zone of perched water; however, the groundwater observed at Site B is more continuous and may be associated with a water table aquifer. A search of well logs (*Montana Bureau of Mines and Geology, Ground Water Information Center Internet Database*) in the vicinity of the potential repository sites revealed that groundwater is fairly shallow in two wells located in relatively close proximity (within approximately a 2-mile radius) to the proposed repository sites. To better characterize local groundwater conditions in the area, a monitoring well network (minimum of 3 wells) is recommended to be installed prior to constructing a repository at either location.

The monitoring well network should be designed to define depth-to-groundwater, groundwater flow direction, and aquifer transmissivity; and ideally, should be monitored for a minimum of one year prior to construction to plot at least one annual hydrograph for the site (high and low groundwater conditions). If the monitoring well network confirms the presence of a shallow water table, the repository could possibly be designed to account for such deficiencies (e.g., shallow excavation depth coupled with a larger surface area, installation of an impermeable liner and/or under-drain system, etc.).

Based on the collected data, the 2004 repository investigation conducted by Pioneer concluded that Site A is the preferred location for disposing of mine wastes from the Snowshoe Mine Site. Site A is preferred for the following reasons:

- Haul distance from the Snowshoe Mine Site to Site A is slightly shorter than the haul route to Site B.

- Significantly less work would be required to provide access for heavy equipment to Site A compared to Site B.

- Groundwater is not as prevalent at Site A compared to Site B.

- Although the soil quality is similar at either location (textural and chemical characteristics), Site A contains significantly less rock (4-inch plus diameter) than Site B. Over-excavation of Site B would be recommended to account for the reject oversize rock.

- Design of the repository could be much more flexible if constructed at Site A due to gentler slopes, much larger available surface area for repository construction, and wider-ranging homogeneous soil conditions.

3.1.4.3 2004 Repository/Borrow Area Investigation - MAXIM

In November 2004, MAXIM Technologies, Inc. (MAXIM) conducted a site investigation for a potential repository/borrow area (Site B-1) under authority of the Kootenai National Forest. Results of the investigation are included in the *Draft Technical Memorandum Site Investigation, Repository Site B-1 Snowshoe Mine and Snowshoe Creek Project* (MAXIM, 2004). The Kootenai National Forest decided to initiate a third repository/borrow investigation because Pioneer had determined that Site A and Site B had shallow groundwater underlying the two sites. The Kootenai National Forest determined that a third site (Site B-1) may be more suitable as a repository site because they felt that no groundwater would be encountered at this location (see Figures 3-4 and 3-7).

Objectives of the Site B-1 investigation included:

- Confirm or deny the presence of near-surface groundwater.

- Descriptions of the characteristics and thickness of the soil and subsoil relative to covering and revegetating the repository.

- Evaluation of the construction engineering properties of the soil in the uppermost 10 to 12 feet including lithology, ripability, and the presence of surface or subsurface features that could affect the suitability of the repository.

Site B-1 is located approximately ½ mile north of Site B (Figure 3-4) and is situated topographically higher than Site A or Site B, which minimizes the potential for encountering ground water. Site B-1 encompasses approximately 10 acres and is situated on a gently sloping, heavily timbered ridge.

MAXIM conducted the field investigation on November 16 and 17, 2004. Nine test pits were randomly excavated using a Kobelco SK120 Mark 3 Tracked Excavator. Test pits (Figure 3-7) were excavated to a depth ranging from 11 feet to 16.5 feet below the ground surface.

Samples were collected from the test pit profile based on changes in lithology and soil type, and were analyzed for physical parameters (USDA soil classification, grain size, coarse fragments) and chemical parameters (% organic, nitrogen, phosphorus, potassium, pH, cations, Electrical Conductivity [EC], ABA, and neutralization potential). Two topsoil samples and nine subsoil samples were collected; although, only seven of the subsoil samples were analyzed because of the overall consistency of the soil encountered at the investigation area. Analytical data are provided in Tables A3-6, A3-7, and A3-8 of Appendix A3.

Results of the site investigation indicate that soils in the area consist of 12 to 14 inches of topsoil with a subsurface consisting of glacial till. Two distinct types of glacial till were apparent beneath the topsoil horizon. These two subsoil horizons consisted of a loosely consolidated light brown glacial till that ranged in thickness from one to four feet below the ground surface across the site and a tightly consolidated brownish yellow glacial till that was encountered at depths ranging from two to five feet below ground surface.

Visual evaluation of the rock content in glacial till horizons generally indicated poorly sorted gravel that is less than one inch to less than three inches in diameter and cobbles up to 12 inches in diameter. Test pits exhibited coarse fragments ranging from 5 to 10% gravels and 2 to 3% cobbles although coarse fragment content for the subsoil samples ranged from 28 to 60% on a weight basis.

Surface soils were classified as loam and silt loam with low organic content (2.2 to 2.8%) and low in nitrogen, phosphorus, and potassium. Soil pH ranged from 5.2 to 5.6. The EC was low (0.09 millimhos/centimeter). Subsoil samples were classified as sandy-loam and silty-loam with low organic content (0.10 to 0.8 %) and low levels of nitrogen, phosphorus, and potassium. Soil pH ranged from 4.7 to 5.4 with low EC (0.03 to 0.12 millimhos/ centimeter). The ABA results for both the surface and subsurface soil indicate that the soils have negligible neutralization potential.

MAXIM concluded that Site B-1 is suitable as a repository adequate for disposal requirements for waste materials from the Snowshoe Mine Site and also a borrow area. Further, MAXIM determined that groundwater was not present at Site B-1. The low organic content of the soil and the high coarse fragment content would require soil amendments and possible screening of the soil.

The field investigation of the three potential repository sites (3 sites evaluated in 2004) confirmed that all 3 sites would be acceptable for disposal of mine wastes and for obtaining cover soil for the Snowshoe Mine Site. The only uncertainty associated with Site A and Site B involves the presence of shallow groundwater. Based on visual evidence, the groundwater at Site A appears to be an isolated zone of perched water; however, the groundwater observed at Site B is more continuous and may be associated with a water table aquifer. No ground water was encountered at Site B-1.

Based on the data collected to-date, Site B-1 is the preferred location for disposing of mine wastes from the Snowshoe Mine Site for the following reasons:

- Haul distance from the Snowshoe Mine Site to Site B-1 is similar to the haul distance to Site A and Site B.

- Groundwater is not present at Site B-1.

- Soil quality is similar at all three locations with less coarse material present at Site B-1.

Due to existing heavy timber at all three locations, significant clearing and grubbing would be required to prepare either site for construction of a repository. The existing heavy timber and corresponding dense conifer canopy provided interference when surveying the sites as part of this investigation. Consequently, after a site is selected for construction of the repository, and clearing and grubbing activities are completed, a new topographic survey should be completed to be able to determine construction quantities with a greater degree of precision.

Conceptually, the repository/borrow area would encompass approximately 5 acres which would accommodate the maximum amount of waste material (138,500 cubic yards) from the Snowshoe Mine Site and provide the maximum amount of cover soil required (40,000 cubic yards) to reclaim the waste sources. The alternatives evaluation and screening presented in Section 7.0 and Section 8.0 assumes that Site B-1 is the preferred location for the repository/borrow area.

4.0 SUMMARY OF APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Section 121(d)(2) of the Comprehensive Environmental Response and Liability Act (CERCLA), 42 United States Code (USC) § 9621(d)(2), requires that clean-up actions conducted under CERCLA achieve a level or standard of control which at least attains *"any standard, requirement, criteria, or limitation under any Federal environmental law or any [more stringent] promulgated standard, requirement, criteria or limitation under a State environmental or facility siting law... [which] is legally applicable to the hazardous substance concerned or is relevant and appropriate under the circumstances of the release of such hazardous substance or pollutant, or contaminant..."* The standards, requirements, criteria, or limitations identified pursuant to this section are commonly referred to as "ARARs."

Two general types of clean-up actions are recognized under CERCLA: removal actions and remedial actions. A removal action is an action to abate, prevent, minimize, stabilize, mitigate, or eliminate a release or threat of release. This action is often temporarily taken to alleviate the most acute threats or to prevent further spread of contamination until more comprehensive action can be taken. A remedial action is a thorough investigation, evaluation of alternatives, and determination and implementation of a comprehensive and fully protective remedy for the site.

The ARARs may be either "applicable" or "relevant and appropriate" to remedial activities at a site but not both. Applicable requirements are those standards, requirements, criteria, or limitations promulgated under federal or state environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site. A remedial action must satisfy all the jurisdictional prerequisites of a requirement for it to be applicable to the specific remedial action at a CERCLA site.

Relevant and appropriate requirements are those standards, requirements, criteria, or limitations promulgated under federal or state environmental or facility citing laws that, while not "applicable" to hazardous substances, pollutants, contaminants, remedial actions, locations, or other circumstances at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site. Factors which may be considered in making this determination, when the factors are pertinent, are presented in 40 Code of Federal Regulations (CFR) § 300.400(g)(2). They include, among other considerations, examination of the purpose of the requirement and of the CERCLA action, the medium and substances regulated by the requirement and at the CERCLA site, the actions or activities regulated by the requirement and the remedial action contemplated at the site, and the potential use of resources affected by the requirement and the use or potential use of the affected resource at the CERCLA site. The ARARs are divided into contaminant-specific, location-specific, and action-specific requirements. Contaminant-specific requirements govern the release of materials possessing certain chemical or physical characteristics or containing specific chemical compounds into the environment. Contaminant-specific ARARs generally set human or environmental risk-based criteria and protocol which, when applied to site-specific conditions, result in the establishment of numerical action values. These values establish the acceptable amount or concentration of a chemical that may be found in, or discharged to, the ambient environment.

Location-specific ARARs relate to the geographic or physical position of the site, rather than to the nature of site contaminants. These ARARs place restrictions on the concentration of hazardous substances or the conduct of clean up activities due to their location in the environment.

As provided by Section 121 of CERCLA, 42 USC § 9621, only those State standards that are more stringent than any Federal standard and that have been identified by the State in a timely manner are appropriately included as ARARs. Some State standards that are potentially duplicative of Federal standards are identified here to ensure their timely identification and consideration in the event that they are not identified or retained in the Federal ARARs. Duplicative or less stringent standards will be deleted as appropriate when the final determination of ARARs is presented.

The CERCLA defines only Federal environmental laws and State environmental or facility citing laws as ARARs. Remedial design, implementation, and operation and maintenance must nevertheless, comply with all other applicable laws, both state and federal. Many such laws, while not strictly environmental or facility-citing laws, have environmental impacts. Moreover, applicable laws that are not ARARs because they are not environmental or facility-citing laws are not subject to the ARAR waiver provisions, and the administrative, as well as the substantive, provisions of such laws must be observed. A separate list attached to the State ARARs list is a non-comprehensive identification of other state law requirements, which must be observed during remedial design, remedy implementation, operation, or maintenance.

Appendix C provides detailed descriptions of potential Federal and State ARARs. The description of the Federal and State ARARs that follows includes summaries of legal requirements that in many cases attempt to set out the requirement in a simple fashion useful in evaluating compliance with the requirement. In the event of any inconsistency between the law and the summaries in this section, the ARAR is ultimately the requirement as set out in the law, rather than any paraphrase provided here. Tables 4-1 and 4-2 present quick-reference summaries of potential Federal and State ARARs (respectively) for the Snowshoe Mine Site.

Table 4-1. Summary of Preliminary Federal Applicable or Relevant and Appropriate Requirements.

Standard, Requirement Criteria Or Limitation	Citation	Description	ARAR Status
FEDERAL CONTAMINANT-SPECIFIC			
Safe Drinking Water Act	40 USC § 300		Relevant and Appropriate
National Primary Drinking Water Standards	40 CFR Part 141	Establishes health-based standards maximum contaminant levels (MCLs) for public water systems.	Relevant and Appropriate
National Secondary Drinking Water Standards	40 CFR Part 143	Establishes aesthetic-based standards (secondary MCLs) for public water systems.	Relevant and Appropriate
Clean Water Act	33 USC. § 1251-1376		Relevant and Appropriate
Water Quality Standards	40 CFR Part 131 Quality Criteria for Water 1976, 1980, 1986	Sets criteria for water quality based on toxicity to aquatic organisms and human health.	Relevant and Appropriate
National Pollutant Discharge Elimination System (NPDES)	40 CFR Part 122	General permits for discharge from construction.	Relevant and Appropriate
Clean Air Act	42 USC § 7409		
National Primary and Secondary Ambient Air Quality Standards	40 CFR Part 50	Air quality levels that protect public health.	Applicable
Resource Conservation and Recovery Act	42 USC § 6901		
Lists Of Hazardous Waste	40 CFR Part 261, Subpart D	Defines those solid wastes that are subject to regulation as hazardous wastes under 40 CFR Parts 262-265 and Parts 124, 270 and 271.	Applicable

Table 4-1. Summary of Preliminary Federal Applicable or Relevant and Appropriate Requirements (continued)

Standard, Requirement Criteria Or Limitation	Citation	Description	ARAR Status
FEDERAL LOCATION-SPECIFIC			
National Historic Preservation Act	16 USC § 470; 36 CFR Part 800; 40 CFR 6.310(b)	Requires Federal Agencies to take into account the effect of any Federally-assisted undertaking or licensing on any district, site, building, structure, or object that is included in or eligible for inclusion in the National Register of Historic Places and to minimize harm to any National Historic Landmark adversely or directly affected by an undertaking.	Applicable
Archaeological and Historic Preservation Act	16 USC § 469; 40 CFR § 6.301(c)	Establishes procedures to provide for preservation of historical and archaeological data which might be destroyed through alteration of terrain as a result of a Federal construction project or a Federally licensed activity or program.	Applicable
Protection of Wetlands Order	40 CFR Part 6, Appendix A, Executive Order No. 11,990	Avoid adverse impacts associated with destruction or loss of wetlands and avoid support of new construction in wetlands if a practicable alternative exists.	Applicable
Historic Sites, Buildings and Antiquities Act Appendix A, Executive Order No. 11, 990	16 USC §§ 461-467; 40 CFR § 6.301(a)	Requires Federal agencies to consider the existence and location of landmarks on the National Registry of Natural Landmarks to avoid undesirable impacts on such landmarks.	Applicable

Fish and Wildlife Coordination Act	16 USC §§ 2901-2912; 40 CFR Part 6.302(g)	Requires consultation when Federal department or agency proposes or authorizes any modification of any stream or other water body and adequate provision for protection of fish and wildlife resources.	Applicable
Floodplain Management Order	40 CFR Part 6	Requires Federal agencies to evaluate the potential effects of actions they may take in a floodplain to avoid the adverse impacts associated with direct development of a floodplain.	Applicable

Table 4-1. Summary of Preliminary Federal Applicable or Relevant and Appropriate Requirements (continued)

Standard, Requirement Criteria Or Limitation	Citation	Description	ARAR Status
Endangered Species Act	16 USC §§ 1531-1543; 40 CFR 6.302(h); 50 CFR Part 402	Activities may not jeopardize the continued existence of any threatened or endangered species or destroy or adversely modify a critical habitat.	Applicable
Bald Eagle Protection Act	16 USC §§ 668	Requires consultation with the USFWS during reclamation design and reclamation construction to ensure that any cleanup of the site does not unnecessarily adversely affect the Bald Eagle or Golden Eagle.	Applicable
Migratory Bird Treaty Act	16 USC §§ 703	Establishes a federal responsibility for the protection for the international migratory bird resource and requires consultation with the USFWS during reclamation design and reclamation construction to ensure the cleanup of the site does not unnecessarily impact migratory birds. Specific mitigative measures may be identified for compliance with this requirement.	Applicable

Table 4-1. Summary of Preliminary Federal Applicable or Relevant and Appropriate Requirements (continued)

FEDERAL ACTION-SPECIFIC			
Standard, Requirement Criteria Or Limitation	**Citation**	**Description**	**ARAR Status**
Clean Water Act	33 USC § 1342		Relevant and Appropriate
NPDES	40 CFR Part 122	Requires permits for the discharge of pollutants from any point source into waters of the United States.	Relevant and Appropriate
Surface Mining Control and Reclamation Act	30 USC §§ 1201-1328	Protects the environment from effects of surface mining activities.	Relevant and Appropriate
	30 CFR Part 784	Governs underground mining permit applications and minimum requirements for reclamation and operations plans.	Relevant and Appropriate

Table 4-1. Summary of Preliminary Federal Applicable or Relevant and Appropriate Requirements (continued)

Standard, Requirement Criteria Or Limitation	Citation	Description	ARAR Status
Surface Mining Control and Reclamation Act (continued)	30 CFR Part 816	Outlines permanent program performance standards for surface mining activities.	Relevant and Appropriate
Hazardous Materials Transportation Act	49 USC §§ 1801-1813		Relevant and Appropriate
Standards Applicable to Transporters of Hazardous Waste	40 CFR Part 263	Regulates transportation of hazardous waste.	Relevant and Appropriate
Resource Conservation and Recovery Act			
Land Disposal	40 CFR Part 268	Establishes a timetable for restriction of burial of wastes and other hazardous materials.	Applicable
Criteria for Classification of Solid Waste Disposal Facilities and Practices	40 CFR Part 257	Establishes criteria for use in determining which solid waste disposal facilities and practices pose a reasonable probability of adverse effects on health or the environment and thereby constitute prohibited open dumps.	Applicable
Standards for Transporters of Hazardous Waste	40 CFR Part 263	Establishes standards which apply to persons transporting hazardous waste within the U.S. if the transportation requires a manifest under 40 CFR Part 262.	Applicable
Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities	40 CFR Part 264	Establishes minimum national standards which define the acceptable management of hazardous waste for owners and operators of facilities which treat, store, or dispose of hazardous waste.	Applicable

Table 4-1. Summary of Preliminary Federal Applicable or Relevant and Appropriate Requirements (continued)

Standard, Requirement Criteria Or Limitation	Citation	Description	ARAR Status
Occupational Safety And Health Act	29 USC § 655		
Hazardous Waste Operations And Emergency Response	29 CFR 1910.120	Defines standards for employee protection during initial site characterization and analysis, monitoring activities, materials handling activities, training & ER.	Applicable

Table 4-2. Summary of Preliminary State Applicable or Relevant and Appropriate Requirements

Standard, Requirement Criteria Or Limitation	Citation	Description	ARAR Status
STATE CONTAMINANT-SPECIFIC			
Montana Water Quality Act	75-101 et seq., MCA	Laws to prevent, abate, and control the pollution of state waters.	Applicable
Regulations Establishing Ambient Surface Water Quality Standards	ARM 16.20.604-624	Provides the water use classification for various streams and imposes specific water quality standards per classification.	Applicable
Regulations Establishing Ambient Surface Water Quality Nondegradation Standards	ARM 16.20.707-714	Applies nondegradation requirements to any activity which could cause a new or increased source of pollution to State waters and outlines review procedures.	Applicable
Regulations Establishing Waste Treatment Standards	ARM 16.20.631-633	Imposes waste treatment requirements to restore and maintain the quality of surface waters to applicable water use categories. Treatment standards are based on the State's policy of nondegradation, and present and anticipated beneficial uses of the receiving waters.	Applicable
	ARM 16.20.925	Technology-based treatment for MPDES permits.	Applicable
Montana Groundwater Pollution Control System Regulations	ARM 16.20.1002	Classifies groundwater into Classes I through IV based on the present and future most beneficial uses of the groundwater and states groundwater is to be classified to actual quality or actual use, whichever places the groundwater in a higher class.	Applicable
	ARM 16.20.1003	Establishes groundwater quality standards for groundwater classification, and should be consulted.	Applicable

Table 4-2. Summary of Preliminary State Applicable or Relevant and Appropriate Requirements (continued)

Standard, Requirement Criteria Or Limitation	Citation	Description	ARAR Status
Montana Groundwater Pollution Control System Regulations (continued)	ARM 16.20.1011	Requires that any groundwater whose existing quality is higher than the standard for its classification must be maintained at that high quality unless degradation is allowed under the principles established in 75-3-303 MCA, and the nondegradation rules at ARM 16.20.706 et.seq.	Applicable
Public Water Supplies Act	75-6-101, MCA	Establishes public policy of MT to "protect, maintain, and improve the quality and potability of water for public water supplies and domestic uses".	Relevant and Appropriate
Public Water Supply Regulations	ARM 16.20.204	Establishes maximum contaminant levels (MCLs) for inorganic chemicals in community water systems.	Relevant and Appropriate
	ARM 16.20.205	Establishes the maximum turbidity contaminant levels for public water supply systems which use surface water in whole or in part.	Relevant and Appropriate
	ARM 16.20.922	Adopts and incorporates language for toxic pollutant effluent standards found in 40 CFR Part 129.	Relevant and Appropriate
	ARM 16.20.923	Adopts and incorporates language for effluent limitations and standards of performance found in 40 CFR Subpart N (except 40 CFR Part 403).	Relevant and Appropriate

Table 4-2. Summary of Preliminary State Applicable or Relevant and Appropriate Requirements (continued)

Standard, Requirement Criteria Or Limitation	Citation	Description	ARAR Status
Clean Air Act Of Montana	75-2-102, MCA	It is Montana's policy is to achieve and maintain such levels of air quality as will protect human health and safety and, to the greatest degree practicable, prevent injury to plant and animal life and property.	
Air Quality Regulations	ARM 16.8.815	No person shall cause or contribute to concentrations of lead in the ambient air which exceed the following 90-day average: 1.5 micrograms per cubic meter of air.	Applicable
	ARM 16.8.818	No person shall cause or contribute to concentrations of particulate matter in the ambient air such that the mass of settled particulate matter exceeds the following 30-day average: 10 grams per square meter.	Applicable
	ARM 16.8.821	No person may cause or contribute to concentrations of PM-10 in the ambient air which exceed the following standard: 1) 24-hr. avg.: 150 micrograms per cubic meter of air, with no more than one expected exceedance per year; 2) Annual avg.: 50 micrograms per cubic meter of air.	Applicable
	ARM 16.8.1302	Lists certain wastes that may not be disposed of by open burning, including oil or petroleum products, RCRA hazardous wastes, chemicals, and treated lumber and timbers.	Relevant and Appropriate

Table 4-2. Summary of Preliminary State Applicable or Relevant and Appropriate Requirements (continued)

Standard, Requirement Criteria Or Limitation	Citation	Description	ARAR Status
Air Quality Regulations (continued)	ARM 16.8.1401	States "no person shall cause or authorize the production, handling, transportation or storage of any material unless reasonable precautions to control emissions of airborne particulate matter are taken."	Applicable
	ARM 16.8.1404	States no person shall cause opacity of 20% over 6 minutes.	Applicable
	ARM 16.8.1424	Sets forth emission standards for hazardous air pollutants.	Applicable
	ARM 26.4.761	Requires a fugitive dust control program be implemented in reclamation operations.	Relevant and Appropriate
Occupational Health Act of Montana	50-70-101, MCA	The purpose of this act is to achieve and maintain such conditions of the work place as will protect human health and safety.	Applicable
Occupational Air Contaminants Requirements	ARM 16.42.102	Establishes maximum threshold limit values for air contaminants believed that nearly all workers may be repeatedly exposed day after day without adverse health effects.	Applicable
Occupational Noise Regulations	ARM 16.42.101	Addresses occupational noise levels and provides that no worker shall be exposed to noise levels in excess of specified levels.	Applicable

Table 4-2. Summary of Preliminary State Applicable or Relevant and Appropriate Requirements (continued)

Standard, Requirement Criteria Or Limitation	Citation	Description	ARAR Status
STATE LOCATION-SPECIFIC			
Floodplain and Floodway Management Act	76-5-401, MCA	Limits the uses permissible in a floodway and generally prohibits permanent structures, fill, or permanent storage of materials or equipment.	Applicable
	76-5-402 MCA	Lists the permissible uses within the floodplain but outside of floodway.	Applicable
	76-5-403, MCA	Lists certain uses which are prohibited in a designated floodway, including any change that will cause water to be diverted from the established floodway, cause erosion, obstruct the natural flow of water, or reduce the carrying capacity of the floodway, or the concentration or permanent storage of an object subject to flotation or movement during flood level periods.	Applicable
Floodplain Management Regulations	ARM 36.15.216	The factors to consider in determining whether a permit should be issued to establish or alter an artificial obstruction or nonconforming use in the floodplain or floodway are set forth in this section.	Applicable
	ARM 36.15.601	Open space uses allowed in the floodway without a permit.	Applicable
	ARM 36.15.602	Uses allowed in the floodway, which require a permit.	Applicable

Table 4-2. Summary of Preliminary State Applicable or Relevant and Appropriate Requirements (continued)

Standard, Requirement Criteria Or Limitation	Citation	Description	ARAR Status
Floodplain Management Regulations (continued)	ARM 36.15.603	Proposed diversions or changes in place of diversions must be evaluated by DNRC to determine whether they may significantly affect flood velocities.	Applicable
	ARM 36.15.604	Prohibits new artificial obstructions or nonconforming uses that will significantly increase the upstream elevation of the base flood 0.5 feet or significantly increase flood velocities.	Applicable
	ARM 36.15.605	Identifies artificial obstructions and nonconforming uses that are prohibited within the designated floodway except as allowed by permit and includes "a structure or excavation that will cause water to be diverted from the established floodway, cause erosion, obstruct the natural flow of water, or reduce the carrying capacity of the floodway...". Solid waste disposal and storage of highly toxic, flammable, or explosive materials are also prohibited.	Applicable
	ARM 36.15.606	Identifies flood control works that are allowed with designated floodways pursuant to permit and certain conditions including: flood control levies and flood walls, riprap, channelization projects, and dams.	Applicable
	ARM 36.15.701	Describes allowed uses in the flood fringe.	Applicable

Table 4-2. Summary of Preliminary State Applicable or Relevant and Appropriate Requirements (continued)

Standard, Requirement Criteria Or Limitation	Citation	Description	ARAR Status
Floodplain Management Regulations (continued)	ARM 36.15.703	Prohibited uses within the flood fringe including solid and hazardous waste disposal and storage of toxic, flammable, or explosive materials.	Applicable
	ARM 36.15.801	Allowed uses where the floodway is not designated or where no flood elevations are available.	Applicable
<u>Natural Streambed and Land Preservation Standards</u>	87-5-501, 502, and 504, MCA	Fish and wildlife resources are to be protected and no construction project or hydraulic project shall adversely affect game or fish habitat.	Applicable
	ARM 36.2.404	Proposed projects are to be evaluated by the appropriate conservation district based on criteria : 1) whether the project will pass anticipated sediment loads without creating harmful flooding or erosion problems upstream or downstream; 2) whether the project will minimize the amount of stream channel alteration; 3) whether the project will be as permanent a solution as possible and whether the method used will create a reasonably permanent and stable situation; 4) whether the project will minimize effects of fish and aquatic habitat; 5) whether the project will minimize turbidity or other water pollution problems; and , 6) whether the project will minimize adverse effects on the natural beauty of the area.	Applicable

Table 4-2. Summary of Preliminary State Applicable or Relevant and Appropriate Requirements (continued)

Standard, Requirement Criteria Or Limitation	Citation	Description	ARAR Status
Antiquities Act	22-3-424, MCA	Heritage and paleontological sites are given appropriate consideration.	Relevant and Appropriate
	22-3-433, MCA	Evaluation of environmental impacts include consultation with State Historic Preservation Officer (SHPO).	Relevant and Appropriate
	2-3-435, MCA	A heritage or paleontological site is to be reported to the SHPO.	Relevant and Appropriate
Cultural Resource Regulations	ARM 12.8.503-508	Procedures to ensure adequate consideration of cultural values.	Relevant and Appropriate
STATE ACTION SPECIFIC			
Montana Water Quality Act	75-5-605, MCA	Pursuant to this section, it is unlawful to cause pollution of any state waters, to place any wastes in a location where they are likely to cause pollution of any state waters, to violate any permit provision, to violate any provision of the Montana Water Quality Act, to construct, modify, or operate a system for disposing of waste (including sediment, solid waste and other substances that may pollute state waters) which discharge into any state waters without a permit or discharge waste into any state waters.	Applicable
Montana Surface Water Quality Regulations	ARM 16.20.631	Industrial waste must receive treatment equivalent to the best practicable available control technology.	Applicable
	ARM 16.20.604-624	Provides for classification of state waters.	Applicable

Table 4-2. Summary of Preliminary State Applicable or Relevant and Appropriate Requirements (continued)

Standard, Requirement Criteria Or Limitation	Citation	Description	ARAR Status
Montana Surface Water Quality Regulations (continued)	ARM 16.20.625	Technology-based treatment for MPDES permits.	Applicable
	ARM 16.20.633	Requires that the State's surface waters be free from, among other things, substances that will create concentrations or combinations of materials that are harmful to human, animal, plant, or aquatic life. Moreover, no waste may be discharged and no activities may be conducted that can reasonably be expected to violate any of the standards.	Applicable
Nondegradation of Water Quality	ARM 16.20.708-714	Applies nondegradation requirements to any activity which would cause a new or increased source of pollution to state waters and outlines review procedures.	Applicable
<u>Montana Groundwater Act</u>			
Montana Groundwater Pollution Control System Regulations	ARM 16.20.1011	Requires that any ground water whose existing quality is higher than the standard for its classification must be maintained at that high quality in accordance with 75-5-303, MCA, and ARM 16.2.701 <u>et.seq</u>.	Applicable
	ARM 16.20.1002	Classifies groundwater into Classes I through IV based on the present and future most beneficial uses of the groundwater and states groundwater, and states that groundwater is to be classified to actual quantity or actual use, which ever places the groundwater in a higher class.	Applicable

Table 4-2. Summary of Preliminary State Applicable or Relevant and Appropriate Requirements (continued)

Standard, Requirement Criteria Or Limitation	Citation	Description	ARAR Status
Montana Groundwater Pollution Control System Regulations (continued)	ARM 16.20.1003	Establishes groundwater quality standards for groundwater classification.	Applicable
<u>Clean Air Act Of Montana</u>	75-2-102, MCA	It's Montana's policy is to "achieve and maintain such levels of air quality as will protect human health and safety and, to the greatest degree practicable, prevent injury to plant and animal life and property, foster the comfort and convenience of the people, promote the economic and social development of this state, and facilitate the enjoyment of the natural attractions of this state".	Applicable
Air Quality Requirements	ARM 16.8.815	No person shall cause or contribute to concentrations of lead in the ambient air which exceed the following 90-day average: 1.5 micrograms per cubic meter of air.	Applicable
	ARM 16.8.1302	Lists certain wastes that may not be disposed of by open burning.	Applicable
	ARM 16.8.1401 and 1404	No person shall cause or authorize the production, handling, transportation or storage of any material unless reasonable precautions to control emissions of airborne particulate matter are taken.	Applicable
<u>Montana Solid Waste Management Act</u>	75-10-201 <u>et.seq</u>., MCA	Public policy is to "control solid waste management systems to protect the public health and safety and to conserve natural resources whenever possible".	Applicable

Table 4-2. Summary of Preliminary State Applicable or Relevant and Appropriate Requirements (continued)

Standard, Requirement Criteria Or Limitation	Citation	Description	ARAR Status
Solid Waste Management Regulations	ARM 16.14.505 and 508-509	The standards for solid waste disposal are set forth in this provision and include: preclusion against location of solid waste disposal sites in a 100-year floodplain, a requirement that sites be located only in areas that will prevent the pollution of ground and surface waters and public and private water supplies, a requirement for drainage structures to be installed where necessary to prevent surface runoff from entering disposal areas and a requirement that sites be located to allow for reclamation. The standards also provide the process for applying for a solid waste management system license and operation and maintenance plan requirements.	Applicable
	ARM 16.14.520-521	General operational and maintenance requirements for solid waste management facilities.	Applicable
	ARM 16.14.523	Solid waste must be transported in such a manner as to prevent its discharge, dumping, spilling or leaking from the transport vehicle.	Applicable
Montana Hazardous Waste Act and Underground Storage Tank Act	5-10-402, MCA	It's the policy of the State to "protect the public health and safety, the health of living organisms, and the environment from the effects of the improper, inadequate, or unsound management of hazardous wastes".	Applicable

Table 4-2. Summary of Preliminary State Applicable or Relevant and Appropriate Requirements (continued)

Standard, Requirement Criteria Or Limitation	Citation	Description	ARAR Status
Montana Hazardous Waste Regulations	ARM 17.54.701-705	By reference to federal regulatory requirements, these sections establish standards for all permitted hazardous waste management facilities. 1) 40 CFR 264.11 (incorporated by reference in ARM 17.54.702) establishes that hazardous waste management facilities must be closed in such a manner as to minimize the need for further maintenance and to control, minimize or eliminate, to the extent necessary to protect public health and the environment, post-closure escape of hazardous wastes, hazardous constituents, leachate, contaminated runoff or hazardous waste decomposition products to the ground or surface waters or the atmosphere. 2) 40 CFR 264.228(a) (incorporated by reference by ARM 17.54.702) requires that at closure, free liquids must be removed or solidified, the wastes stabilized and the waste management unit covered. 3) 40 CFR 264.228 and 310 (incorporated by reference by ARM 17.54.702) requires that surface impoundments and landfill caps must: (a) provide long-term minimization of migration of liquids through the unit; (b) function with minimum maintenance; (c) promote drainage and minimize erosion or abrasion of the final cover;	Relevant and Appropriate

Table 4-2. Summary of Preliminary State Applicable or Relevant and Appropriate Requirements (continued)

Standard, Requirement Criteria Or Limitation	Citation	Description	ARAR Status
Montana Hazardous Waste Regulations (continued)	ARM 17.54.701-705 (continued)	d) accommodate settling and subsidence; and (e) have a permeability less than or equal to the permeability of the natural subsoil present. 4) 40 CFR 264.119 (incorporated by reference in ARM 17.54.702) requires that, no later than 60 days after certification of closure of each hazardous waste disposal unit, the owner or operator submit a record of the type, location, and quantity of hazardous waste disposed in each unit. The regulation also gives time limits for recording a deed restriction, in accordance with state law, that will, in perpetuity, notify potential purchasers that the property has been used for waste disposal and that its use is restricted.	
	ARM 17.54.111-119	Establishes permit conditions, duration of permits, schedules of compliance, and requirements for recording and reporting.	
	ARM 17.54.130-131	Establishes contents of permit application.	
<u>Montana Strip and Underground Mine Reclamation Act</u>	82-4-231, MCA	Sets forth objectives that require the operator to reclaim and revegetate the land affected by his operation.	Relevant and Appropriate

Table 4-2. Summary of Preliminary State Applicable or Relevant and Appropriate Requirements (continued)

Standard, Requirement Criteria Or Limitation	Citation	Description	ARAR Status
Montana Strip and Underground Mine Reclamation Act (continued)	82-4-233, MCA	Requires that after the operation has been backfilled, graded, topsoiled and approved, the operator shall establish a vegetative cover on all impacted lands.	Relevant and Appropriate
		Specifications for the vegetative cover and performance are provided.	Relevant and Appropriate
Backfilling and Grading Requirements	ARM 26.4.501	Gives general backfilling and grading requirements.	Relevant and Appropriate
	ARM 26.4.501A	Final grading requirements.	Relevant and Appropriate
	ARM 26.4.504	Provides that permanent impoundments may be retained under certain circumstances.	Relevant and Appropriate
	ARM 26.4.514	Gives contouring requirements.	Relevant and Appropriate
	ARM 26.4.519	The operator may be required to monitor settling of regraded areas.	Relevant and Appropriate
	ARM 26.4.520	Spoil material may be disposed of on-site in accordance with requirements of this section. Contains specific requirements for siting, surface runoff, construction of underdrains and revegetation.	Relevant and Appropriate
Hydrology Requirements	ARM 26.4.631	Reclamation operations must be planned and conducted to minimize disturbance to the prevailing hydrologic balance and to prevent material damage to the prevailing hydrologic balance.	Relevant and Appropriate

Table 4-2. Summary of Preliminary State Applicable or Relevant and Appropriate Requirements (continued)

Standard, Requirement Criteria Or Limitation	Citation	Description	ARAR Status
Hydrology Requirements (continued)	ARM 26.4.633	Specifies that sediment controls must be maintained until the disturbed area has been restored and revegetation established.	Relevant and Appropriate
	ARM 26.4.634	Drainage design shall emphasize channel and floodplain pre-mining configuration that blends with the undisturbed drainage system above and below, and will meander naturally, remain in dynamic equilibrium with the system, improve unstable pre-mining condition, provide for floods, provide for long term stability of landscape, and establish a pre-mining diversity of aquatic habitats and riparian vegetation.	Relevant and Appropriate
	ARM 26.4.635-637	Sets forth requirements for temporary and permanent diversions.	Relevant and Appropriate
	ARM 26.4.638	Sediment control measures shall be designed using the best technology currently available to prevent additional sediment to stream flows, meet the more stringent of federal or state effluent limitation, and minimize erosion.	Relevant and Appropriate
	ARM 26.4.640	Provides that discharge from sedimentation ponds, permanent and temporary impoundments, and diversions shall be controlled by energy dissipaters, riprap channels, and other devices, where necessary, to reduce erosion, prevent deepening or enlargement of stream channels, and to minimize disturbance of the hydrologic balance.	Relevant and Appropriate

Table 4-2. Summary of Preliminary State Applicable or Relevant and Appropriate Requirements (continued)

Standard, Requirement Criteria Or Limitation	Citation	Description	ARAR Status
Hydrology Requirements (continued)	ARM 26.4.641	Sets forth methods for prevention of drainage from acid-and toxic-forming spoils into ground and surface waters.	Relevant and Appropriate
	ARM 26.4.642	Prohibits permanent impoundments with certain exceptions, and sets standards for temporary and permanent impoundments.	Relevant and Appropriate
	ARM 26.4.643-646	Provide for groundwater protection, groundwater recharge protection, and surface and groundwater monitoring.	Relevant and Appropriate
	ARM 26.4.649	Prohibits the discharge, diversion, or infiltration of surface and groundwater into existing underground mine workings.	Relevant and Appropriate
	ARM 26.4.650	All permanent sedimentation ponds, diversions, impoundments, and treatment facilities must be renovated post-mining, to meet criteria specified in the design plan. All such temporary structures shall be regraded to the approximate original contour.	Relevant and Appropriate
Top Soiling, Revegetation, and Protection of Wildlife and Air Resource Regulations	ARM 26.4.701-702	Requirements for stockpiling soil.	Relevant and Appropriate
	ARM 26.4.703	Materials other than, or along with, soil for final surfacing of spoils or other disturbances must be capable of supporting the approved vegetation and post-mining land use.	Relevant and Appropriate

Table 4-2. Summary of Preliminary State Applicable or Relevant and Appropriate Requirements (continued)

Standard, Requirement Criteria Or Limitation	Citation	Description	ARAR Status
Top Soiling, Revegetation, and Protection of Wildlife and Air Resource Regulations (continued)	ARM 26.4.711	The section requires "a diverse, effective, and permanent vegetative cover of the same seasonal variety native to the area affected and capable of meeting the criteria set forth in 82-4-233 shall be established on all areas of land affected except water areas and surface areas of roads".	Relevant and Appropriate
	ARM 26.4.713	Specifies that seeding and planting of disturbed areas must be conducted during the first appropriate period for favorable planting after final seedbed preparation; but not longer than 90 days after top soil placement.	Relevant and Appropriate
	ARM 26.4.714	According to this section, as soon as practical, a mulch or cover crop must be used on all regraded and resoiled areas to control erosion, to promote germination of seeds, and to increase moisture retention of soil until permanent cover is established.	Relevant and Appropriate
	ARM 26.4.716	Establishes the required method of revegetation and provides that introduced species may be substituted for native species as part of an approved plan.	Relevant and Appropriate
	ARM 26.4. 717	Whenever tree species are necessary, trees adapted for local site conditions and climate shall be used.	Relevant and Appropriate

Table 4-2. Summary of Preliminary State Applicable or Relevant and Appropriate Requirements (continued)

Standard, Requirement Criteria Or Limitation	Citation	Description	ARAR Status
Top Soiling, Revegetation, and Protection of Wildlife and Air Resource Regulations (continued)	ARM 26.4.718	Soil amendments must be used as necessary to aid in the establishment of permanent vegetation. Irrigation, management, fencing, or other measures may also be used after review and approval by the department.	Relevant and Appropriate
	ARM 26.4.719	Livestock grazing on reclaimed land is prohibited until revegetation is established and can sustain managed grazing.	Relevant and Appropriate
	ARM 26.4.720	Sets annual department inspection requirements.	Relevant and Appropriate
	ARM 26.4.721	Section specifies that rills and gullies greater than 9 inches which form on the reclaimed area must be filled, graded or otherwise stabilized and the area reseeded.	Relevant and Appropriate
	ARM 26.4.723	Monitoring of vegetation, soils and wildlife.	Relevant and Appropriate
	ARM 26.4.724	Success of revegetation shall be measured on the basis of unmined reference areas.	Relevant and Appropriate
	ARM 26.4.725	Sets periods of responsibility and evaluation.	Relevant and Appropriate
	ARM 26.4.726	Sets means of measuring productivity.	Relevant and Appropriate
	ARM 26.4.728	Sets requirements for composition of vegetation.	Relevant and Appropriate

Table 4-2. Summary of Preliminary State Applicable or Relevant and Appropriate Requirements (continued)

Standard, Requirement Criteria Or Limitation	Citation	Description	ARAR Status
Top Soiling, Revegetation, and Protection of Wildlife and Air Resource Regulations (continued)	ARM 26.4.730-731	Revegetated area must furnish palatable forage in comparable quantity and quality during the same grazing period as the reference area.	Relevant and Appropriate
	ARM 26.4.733	Sets requirements and measurement standards for trees, shrubs, and half-shrubs.	Relevant and Appropriate
	ARM 26.4.751	Section requires that site activities must be conducted so as to avoid or minimize impacts to important fish and wildlife species, including critical habitat and any threatened and endangered species identified at the site.	Relevant and Appropriate
	ARM 26.4.761	Section requires fugitive dust control measures for site preparation and reclamation operations.	Relevant and Appropriate

5.0 BASELINE HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENTS

5.1 HUMAN HEALTH RISK ASSESSMENT

The baseline human health risk assessment performed for the Snowshoe Mine Site follows the Federal Remedial Investigation/Feasibility Study (RI/FS) process for CERCLA (Superfund) sites. The key guidance documents used were EPA's *Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual Part A Interim Final* (EPA, 1989a) and *Risk Assessment Guidance for Superfund; Volume I-Human Health Evaluation Manual Part B* (EPA , 1991). The baseline human health risk assessment examines the effects of taking no further remedial action at the site. This abbreviated assessment involves two steps: hazard identification and risk characterization. These tasks are accomplished by evaluating available data and selecting Contaminants of Concern (COCs), comparing those concentrations to previously derived risk-based clean up concentrations, and characterizing overall risk by integrating the results of the comparison.

General problems at the Snowshoe Mine Site that could impact human health include elevated concentrations of metals and arsenic in waste materials, surface water and stream sediments. The easily accessible waste materials may result in significant health-related consequences to the human population.

5.1.1 Hazard Identification

The initial task of the risk assessment is to select the COCs at the site, to identify those that pose significant potential human health risks. Standard criteria for this selection include: 1) those contaminants that are associated with and are present at the site; 2) contaminants in waste sources with concentrations significantly above background levels; 3) contaminants with at least 20% of the measured concentrations above the detection limit; and 4) contaminants with acceptable quality assurance/quality control (QA/QC) results applied to the data.

At the Snowshoe Mine Site, waste rock, mill tailings, surface water, and stream sediments were analyzed for a list of 16 elements. Eight of these elements are present at the site at concentrations significantly above background levels, with 20% of the samples detected above the corresponding detection limit, these include: arsenic, cadmium, copper, mercury, lead, antimony, silver, and zinc. These eight COCs are selected for detailed evaluation because they are present in significant concentrations in wastes, stream sediments, and surface water at the site.

5.1.2 Exposure Scenarios

The following section describes the exposure scenarios assumed for the Snowshoe Mine Site. The exposure assessment identifies the potentially exposed population(s) and exposure pathways, and estimates exposure point concentrations and contaminant intakes. The previously derived risk-based clean up goals were calculated using two exposure scenarios: a recreational use scenario as stated in the *Risk-Based Clean-up Guidelines for Abandoned Mine Sites* (Tetra Tech, 1996) and a residential use scenario as stated in the *Risk-Based Concentration Table, April 2002 Update* (Smith, 2002).

The residential use risk-based concentrations involve residential occupation of the contaminated land with the maximum level of exposure occurring for a child 0 to 6 years old (soil ingestion route). The resultant risk-based concentrations were derived for this worst-case residential exposure scenario by EPA Region III (Smith, 2002). The soil ingestion and dust inhalation exposure routes assumed surface concentrations equal to the average of the surficial waste samples collected in the 2002 site investigation. The drinking water ingestion route utilized the groundwater concentrations measured at monitoring well sample GW-3.

The DEQ/MWCB has provided a measure of the health risks to recreational populations exposed to mine wastes in a report titled *Risk-Based Cleanup Guidelines for Abandoned Mine Sites* (Tetra Tech, 1996). These risk-based guidelines were developed using a risk assessment that assumed four types of recreation populations: fishermen, hunters, gold panners/rockhounds and ATV/motorcycle riders. The maximum risk calculated for the applicable recreational exposure scenarios was for the gold panner/rockhound (waste rock and surface water exposures only). The soil ingestion and dust inhalation exposure routes assumed a surface concentration equal to the average of the surficial waste samples collected in the 2002 site investigation. This surficial waste represents material likely to be contacted directly prior to ingestion and most likely to be suspended as dust. The water ingestion routes used the maximum in-stream surface water concentrations at the Snowshoe Mine Site sampled in 2002 for drinking water.

5.1.3 Toxicity Assessment

The toxicity assessment examines the potential for the COCs to cause adverse effects in exposed individuals and provides an estimate of the dose-response relationship between the extent of exposure to a particular contaminant and adverse effects. Adverse effects include both non-carcinogenic and carcinogenic health effects in humans. Sources of toxicity data include the EPA's Integrated Risk Information System (IRIS), Agency for Toxic Substances and Disease Registry (ATSDR) Toxicological Profiles, Health Effects Assessment Summary Tables (HEAST), and EPA criteria documents. Individual toxicity profiles for each COC are not presented here; however, they are provided in the reference documents (Smith, 2002; Tetra Tech, 1996). The existing risk-based concentrations that were used to characterize risks from exposure to the COCs for each exposure scenario are presented in Tables 5-1 (residential scenario) and 5-2 (recreational scenario). The risk values correspond to a lifetime cancer risk of $1x10^{-6}$ (one in one million) or hazard quotients (HQs) equal to 1.0.

TABLE 5-1

SNOWSHOE MINE SITE
RISK-BASED CONCENTRATIONS FOR CONTAMINANTS OF CONCERN
FOR THE RESIDENTIAL SCENARIO

Contaminant of Concern	Residential Soil Ingestion (soil conc.) mg/kg	Residential Dust Inhalation (soil conc.) mg/kg	Residential Water Ingestion µg/L
Antimony	31	NA	15
Arsenic	23 0.43 (Carc.)	740,000 380 (Carc.)	11 0.045 (Carc.)
Cadmium	39	140,000 920 (Carc.)	18
Copper	3,100	NA	1,500
Lead	400*	NA	15*
Mercury	23	7	11
Silver	390	NA	180
Zinc	23,000	NA	11,000

NA = Not Applicable, concentration is more than unity.
Carc = Carcinogenic RBC
*Lead levels derived from USEPA recommendations, not RBC table (Smith, 2002).
mg/kg – milligrams per kilogram
µg/L – micrograms per Liter

TABLE 5-2
SNOWSHOE MINE SITE
RISK-BASED CONCENTRATIONS FOR CONTAMINANTS OF CONCERN
FOR THE RECREATIONAL SCENARIO

Contaminant of Concern	Recreational Soil Ing./Inh.-Waste Rock mg/kg	Recreational Water Ingestion µg/L
Antimony	586	204
Arsenic	323 1.4 (Carc.)	153 0.7 (Carc.)
Cadmium	1,750 22 (Carc.)	256
Copper	54,200	18,900
Lead	2,200	220
Mercury	440	153
Silver	NA	NA
Zinc	440,000	153,000

NA = Not Applicable, concentration is more than unity.
Carc. = Carcinogenic
mg/kg – milligrams per kilogram
µg/L – micrograms per Liter

5.1.4 Risk Characterization

<u>Residential Land Use Scenario</u>

The residential exposure assumptions utilized to estimate contaminant intakes were compared to the risk-based concentrations (RBCs) in Table 5-1. These data were used to calculate resultant human health non-carcinogenic HQs and carcinogenic risk values for each COC. The results of the risk calculations for the residential land use scenario at the Snowshoe Mine Site are summarized in Table 5-3.

TABLE 5-3
SNOWSHOE MINE SITE
SUMMARY OF NON-CARCINOGENIC HAZARD QUOTIENTS (HQs) AND CARCINOGENIC RISK VALUES FOR THE RESIDENTIAL LAND USE SCENARIO

Non-Carcinogenic HQ Summary	Soil Ingestion	Water Ingestion	Dust Inhalation	Total
Antimony	5.1613	0.4933	0.0002	5.6548
Arsenic	117.8261	38.8182	0.0037	156.6479
Cadmium	14.2308	1.4722	0.0040	15.7070
Copper	0.1706	0.0000	0.0005	0.1712
Lead	160.7150	206.6667	0.0643	367.4460
Mercury	0.0352	0.0027	0.1157	0.1537
Silver	0.2426	0.0433	0.0001	0.2860
Zinc	0.8772	0.2164	0.0202	1.1138
Total HQ - Non-Carcinogenic	299.2588	247.7128	0.2086	547.1802
Carcinogenic Risk Summary				
Arsenic	6.30E-03	9.49E-03	7.13E-06	1.58E-02
Cadmium	NC	NC	6.03E-07	6.03E-07
Total Risk - Carcinogenic	6.30E-03	9.49E-03	7.73E-06	1.58E-02

NC = Not Calculated because no RBC is provided.

The HQ values exceed 1.0 for the residential land use scenario for 4 COCs (antimony, arsenic, cadmium, and lead) via 2 exposure pathways. The HQ values greater than 1.0 indicate the potential for harmful effects by a COC via the specified pathway. Soil ingestion of lead, arsenic, cadmium, antimony, and water ingestion of lead and arsenic comprise the majority of the potential residential non-carcinogenic risk at the site.

The lower part of Table 5-3 (carcinogenic risk), indicates that the residential exposure to COCs (only arsenic and cadmium have carcinogenic RBCs) at the site results in a total carcinogenic risk of 1.58E-02, which exceeds one per million (1.00E-06) exposed individuals by four orders of magnitude. The EPA utilizes a 1.00E-06 value as a point of departure in assessing the need for contaminant clean up at a particular site. The route-specific risk values which exceed 1.00E-06 are from arsenic via the following: soil ingestion (6.30E-02); water ingestion (9.49E-03); and dust inhalation (7.13E-05).

Recreational Land Use Scenario
The recreational exposure assumptions utilized to estimate contaminant intakes were compared to the risk-based concentrations in Table 5-2. These data were used to calculate resultant human health carcinogenic risk values and non-carcinogenic HQs for each COC. The results of the risk calculations for the recreational land use scenario at the Snowshoe Mine Site are summarized in Table 5-4.

TABLE 5-4
SNOWSHOE MINE SITE
SUMMARY OF NON-CARCINOGENIC HAZARD QUOTIENTS (HQs) AND CARCINOGENIC RISK VALUES FOR THE RECREATIONAL LAND USE SCENARIO

Non-Carcinogenic HQ Summary	Soil Ingestion/ Dust Inhalation	Water Ingestion	Total
Antimony	0.3225	0.0054	0.3279
Arsenic	8.0495	0.0176	8.0672
Cadmium	0.3851	0.0234	0.4086
Copper	0.0109	0.0002	0.0111
Lead	34.5036	0.0945	34.5982
Mercury	0.0022	0.0002	0.0024
Silver	0.0001	0.0000	0.0001
Zinc	0.0540	0.0023	0.0563
Total HQ - Non-Carcinogenic	43.3280	0.1437	43.4717
Carcinogenic Risk Summary			
Arsenic	1.87E-03	1.71E-05	1.89E-03
Cadmium	3.12E-05	NC	3.12E-05
Total Risk - Carcinogenic	1.90E-03	1.71E-05	1.92E-03

NC = Not Calculated because no RBC is provided.

Inspection of the HQs in Table 5-4 yields the following observations. First, HQ values exceed 1.0 for 2 COCs (lead and arsenic) via the soil/dust exposure route. The HQ values greater than 1.0 indicate the potential for harmful effects by a COC via the specified pathway(s). The soil/dust pathway total HQ of 43.33 indicates that this exposure pathway presents the greatest likelihood of adverse human health effects for the recreational scenario.

The lower part of Table 5-4 (carcinogenic risk), reveals that the recreational exposure to COCs (only arsenic and cadmium have RBCs) at the site results in a total carcinogenic risk of 1.92E-03, which exceeds one per million (1.00E-06) exposed individuals by three orders of magnitude. The EPA utilizes this 1.00E-06 value as a point of departure in assessing the need for contaminant clean up at a particular site. The carcinogenic risk estimates for arsenic of 1.87E-03 via soil ingestion/dust inhalation and 1.71E-05 via water ingestion are therefore, of concern.

5.2 ECOLOGICAL RISK ASSESSMENT

The ecological risk assessment was performed for the Snowshoe Mine Site following Federal RI/FS guidance for CERCLA (Superfund) sites (EPA, 1988). The key guidance documents used were EPA's *Risk Assessment Guidance for Superfund, Volume II, Environmental Evaluation Manual* (EPA, 1989b), and *Ecological Assessment of Hazardous Waste Sites* (EPA, 1989c). The waste materials present at the site pose a potential risk not only to humans but also to other species that come into contact with them. Due to the sparse and indirect nature of the ecologic risk data available for the site, this evaluation is intended as a screening-level ecological risk assessment, and the results are of a qualitative nature.

The ecological risk assessment estimates the effects of taking no action at the site and involves four steps: 1) identification of contaminants and ecologic receptors of concern; 2) exposure assessment; 3) ecologic effects assessment; and 4) risk characterization. These four tasks are accomplished by evaluating available data and selecting contaminants, species and exposure routes of concern, estimating exposure point concentrations and intakes, assessing ecologic toxicity of the COCs, and characterizing overall risk by integrating the results of the toxicity and exposure assessments.

Problems at the Snowshoe Mine Site that could impact ecologic receptors include elevated concentrations of metals and arsenic in waste materials, and elevated concentrations of metals and arsenic in surface water and stream sediments. The easily accessible waste materials may result in significant ecological effects. The objectives of this ecological risk assessment are to estimate current and future effects of implementing the No Action Alternative at the site.

5.2.1 Contaminants and Receptors of Concern

As in the human health risk assessment, contaminants that are significantly above background concentrations and are associated with the site are retained as COCs. Eight of the 16 elements analyzed are present at the site at concentrations significantly above background levels, with 20% of the samples detected above the corresponding detection limit: arsenic, cadmium, copper, lead, mercury, antimony, silver, and zinc. These contaminants are selected for evaluation because they are present in significant concentrations in wastes, stream sediments, and surface water. However, several of these contaminants have no ecologic toxicity data with which to evaluate potential effects.

Two groups of ecologic receptors have been identified as potentially affected by site contamination. The first group of receptors is associated with receiving streams Snowshoe Creek, Big Cherry Creek, and Libby Creek downstream from the site, and includes fisheries, aquatic life, and wetlands. Wetlands of any size are of concern because they typically support a diverse ecologic community. These surface water receptors are evaluated using EPA and

Montana aquatic life criteria, which apply to aquatic organisms only; there are no criteria with which to evaluate wetlands.

The second group of receptors are native terrestrial plant communities, which are notably absent on many of the wastes at the site. They are of concern because native vegetation has not become established on the wastes, which would help reduce the potential for release of wastes into surface water and reduce exposure to surface wastes by human and wildlife receptors.

5.2.2 Exposure Assessment

The two exposure scenarios can be semi-quantitatively assessed. Both the surface water-aquatic life and plant phytotoxicity scenarios can be compared directly to toxicity standards that apply to the respective environmental media.

Surface Water/Sediment - Aquatic Life Scenario
Ecologic exposures via this pathway are threefold: direct exposure of aquatic organisms to surface water concentrations that exceed toxicity thresholds; ingestion of aquatic species (e.g., insects) that have bioaccumulated contaminants to the extent that they are toxic to the predator (e.g., fish); and exposure of aquatic organisms (e.g., fish embryos) to sediment pore water environments that are toxic due to elevated contaminant concentrations in the sediments. Data used for this assessment were collected in Snowshoe Creek (sediment and surface water) during 2002. Water quality and sediment concentration data used for this assessment are presented in Table 5-5, and represent the maximum downstream concentrations found during the 2002 RI.

TABLE 5-5
SNOWSHOE MINE SITE
DOWNSTREAM CONTAMINANT CONCENTRATIONS IN SURFACE WATER AND STREAM SEDIMENT

	As	Cd	Cu	Pb	Ag	Zn
Surface Water –Snowshoe Creek (µg/L)	2.7	6.0	3.3	20.8	<3.7	349
Stream Sediment –Snowshoe Creek (mg/kg)	7,290	350	588	16,200	52.8	28,200

mg/kg – milligrams per kilogram
µg/L – micrograms per Liter

Plant - Phytotoxicity Scenario
This scenario involves the limited ability of various plant species to grow in soils or wastes with high concentrations of site-related contaminants. Table 5-6 presents the contaminant concentrations used for this assessment, which represent the average surface waste concentrations found during the 2002 RI.

TABLE 5-6
SNOWSHOE MINE SITE
AVERAGE CONCENTRATIONS IN SURFACE SOURCES

	As	**Cd**	**Cu**	**Pb**	**Ag**	**Zn**
Surface Source Average (mg/kg)	2,710	555	529	64,286	94.6	20,176

mg/kg – milligrams per kilogram

5.2.3 Ecological Effects Assessment

The known effects of the site COCs are available from several literature sources and are not repeated here. No site-specific toxicity tests were performed to support the ecologic risk assessment, either *in-situ* or at a laboratory. Only existing and proposed toxicity-based criteria and standards were used for this ecological effects assessment.

Surface Water/Sediment - Aquatic Life Scenario
Freshwater acute (1-hour average) water quality criteria have been promulgated by the State of Montana (DEQ/WQB, 2002) for many of the COCs. Several of these criteria are calculated as a function of water hardness and a few are numerical standards. The numerical water quality standards are presented in Table 5-7 and apply to surface waters downstream from the site. Those criteria that are a function of hardness have been calculated for the downstream station used and are presented in Table 5-8.

TABLE 5-7
SNOWSHOE MINE SITE
NUMERICAL WATER QUALITY CRITERIA

Acute Criteria in µg/L	**As**
Snowshoe Creek	340

µg/L – micrograms per Liter

TABLE 5-8
SNOWSHOE MINE SITE
HARDNESS-DEPENDENT WATER QUALITY CRITERIA

Acute Criteria in µg/L	**Cd**	**Cu**	**Pb**	**Ag**	**Zn**
Snowshoe Creek	0.58	3.8	16.1	0.45	40.7

µg/L – micrograms per Liter

Presently, the EPA has not finalized sediment quality criteria. Proposed sediment criteria for metals currently consist of the Effect Range - Low (ER-L) and Effect Range - Median (ER-M) values generated from the pool of national freshwater and marine sediment toxicity information as compiled in *The Potential for Biological Effects of Sediments-Sorbed Contaminants Tested in the National Status and Trends Program, NOAA Technical Memorandum NOS OMA 52* (Long and Morgan, 1991). The ER-M values are probably most appropriate to use for comparison to Snowshoe Creek sediment data and are presented in Table 5-9.

TABLE 5-9
SNOWSHOE MINE SITE
SEDIMENT QUALITY CRITERIA (PROPOSED)

Sediment Criteria in mg/kg	As	Cd	Cu	Pb	Zn
Effect Range - Median (ER-M)	85	9	390	110	270

mg/kg – milligrams per kilogram

Plant - Phytotoxicity Scenario

Information is available on the phytotoxicity for some of the COCs as presented in *Trace Elements in Soils and Plants* (Kabata-Pendias and Pendias, 1989) and these are listed in Table 5-10. The availability of contaminants to plants and the potential for plant toxicity depends on many factors including soil pH, soil texture, nutrients, and plant species.

TABLE 5-10
SNOWSHOE MINE SITE
SUMMARY OF PHYTOTOXIC SOIL CONCENTRATIONS

	As	Cd	Cu	Pb	Zn
Concentration Range (mg/kg, dry wt.)	15-50	3-8	60-125	100-400	70-400

mg/kg – milligrams per kilogram

5.2.4 Risk Characterization

This section combines the ecologic exposure estimates and concentrations presented in Section 5.2.2 and the ecologic effects data presented in Section 5.2.3 to provide a screening level estimate of potential adverse ecologic impacts for the scenarios evaluated. This was accomplished by generating ecologic impact quotients (EQs), analogous to the health HQs calculated for human exposures to non-carcinogens. The COC-specific EQs were generated by dividing the particular intake estimate or concentration by available ecological effect values or concentrations. As with HQs, if EQs are less than 1.0, adverse ecological impacts are not expected at the Snowshoe Mine Site.

Surface Water/Sediment - Aquatic Life Scenario

For this scenario, surface water concentration data are compared to acute aquatic life criteria. Limitations of this comparison include that water quality criteria are not species-specific toxicity levels. They represent toxicity to the most sensitive species, which may or may not be present at the Snowshoe Mine Site, and toxicity to the most sensitive species may not in itself be a limiting factor for the maintenance of a healthy, viable fishery and/or other aquatic organisms. The results of the EQ calculations for this scenario are presented in Table 5-11.

TABLE 5-11
SNOWSHOE MINE SITE
ECOLOGIC IMPACT QUOTIENTS (EQs) FOR THE
SURFACE WATER - AQUATIC LIFE SCENARIO

Location	As	Cd	Cu	Pb	Ag	Zn
Snowshoe Creek	0.008	10.260	0.870	1.288	4.071	8.565

Examination of Table 5-11 indicates the potential for aquatic life impacts (EQs greater than 1.0) due to apparent acute toxicity for cadmium, lead, silver, and zinc in Snowshoe Creek. The elevated and persistent EQs for cadmium, silver, and zinc suggest that these contaminants have the potential to adversely affect aquatic life in Snowshoe Creek.

Similarly, stream sediment concentration data are compared to proposed sediment quality criteria (ER-M). Limitations of this comparison include that these sediment quality criteria are preliminary and are also not species-specific. They represent sediment toxicity to the most sensitive species, which may or may not be present at the Snowshoe Mine Site, and toxicity to the most sensitive species may not in itself be a limiting factor for the maintenance of a healthy, viable fishery and/or other aquatic organisms. The results of these EQ calculations are presented in Table 5-12.

TABLE 5-12
SNOWSHOE MINE SITE
ECOLOGIC IMPACT QUOTIENTS (EQs) FOR THE
SEDIMENT - AQUATIC LIFE SCENARIO

Location	As	Cd	Cu	Pb	Zn
Snowshoe Creek	85.765	38.889	1.508	147.273	104.444

The EQs presented in Table 5-12 indicate the potential for aquatic life impacts (EQs greater than 1.0) due to apparent sediment toxicity for arsenic, cadmium, copper, lead, and zinc in Snowshoe Creek. The elevated and persistent EQs for arsenic, cadmium, lead, and zinc suggest that these contaminants have the potential to adversely affect sediment benthos, fish embryos, and/or macroinvertebrate communities. However, the sediment criteria used to calculate these EQs may not apply to species found in this system.

Plant - Phytotoxicity Scenario
Source surface average concentrations collected at the Snowshoe Mine Site are compared to high values of the range of plant phytotoxicity derived from the literature. Limitations of this comparison include that the phytotoxicity ranges are not species-specific; they represent toxicity to species which may or may not be present at the site. Additionally, other physical or chemical characteristics of the waste materials may create microenvironments which limit growth and survival of terrestrial plants directly or in combination with substrate toxicity. Waste materials are likely to have poor water holding capacity, low organic content, limited nutrients, and may harden enough to resist root penetration. The results of the EQ calculations for this scenario are presented in Table 5-13.

TABLE 5-13
SNOWSHOE MINE SITE
ECOLOGIC IMPACT QUOTIENTS (EQs) FOR THE
PLANT - PHYTOTOXICITY SCENARIO

	As	Cd	Cu	Pb	Zn
Snowshoe Mine Site	54.20	69.38	4.23	160.71	50.44

The EQs presented in Table 5-13 indicate the potential for adverse ecologic impacts to plant communities for the Snowshoe Mine Site. The calculated EQs greater than 1.0 include: arsenic, cadmium, copper, lead, and zinc. The non-conservative assumption of using the high end of the phytotoxicity range to derive these EQs, probably underestimates the potential phytotoxic effect to the plant community. However, several other factors in addition to phytotoxicity combine to adversely affect plant establishment and success on the waste materials.

5.2.5 Risk Characterization Summary

The calculated EQs can be used to assess whether ecologic receptors are exposed to potentially harmful doses of site-related contaminants via the ecologic scenarios evaluated. The EQs for each of the scenarios at the Snowshoe Mine Site are presented in Table 5-14 to estimate a combined ecologic EQ for each scenario and each contaminant. The results of combining the ecologic scenarios are also summarized in Table 5-14.

TABLE 5-14
SNOWSHOE MINE SITE
SUMMARY OF ECOLOGIC QUOTIENT (EQ) VALUES

Ecologic EQ Summary	Surface Water	Sediment	Plant Toxicity	Total
Arsenic	0.008	85.765	54.20	139.973
Cadmium	10.260	38.889	69.38	118.529
Copper	0.870	1.508	4.23	6.608
Lead	1.288	147.273	160.71	309.271
Silver	4.071	NC	NC	4.071
Zinc	8.565	104.444	50.44	163.449
Total EQ	25.062	377.879	338.96	741.901

NC = Not Calculated because no applicable standard exists.

The aquatic life scenario results in EQs as high as 10.26 (surface water - cadmium), and 147.3 (sediments - lead) in Snowshoe Creek. The plant toxicity EQs are as high as 161 (lead). These EQs show that even at the lower boundary of these calculated risk estimates, the ecologic risk characterization demonstrates that contaminants at the site constitute a probable adverse ecologic effect via all three exposure scenarios and justify appropriate clean up. Lead is the primary COC, and terrestrial plants are the primary receptors. Lead, zinc, arsenic, and cadmium in sediment and cadmium and zinc in surface water are secondary contaminants and receptors of concern.

6.0 RECLAMATION OBJECTIVES AND GOALS

6.1 ARAR-BASED RECLAMATION GOALS

6.1.1 Groundwater

Groundwater data were collected at the site from a monitoring well downgradient from the site wastes (GW-3). Results from the sample collected in 2002 indicate that several contaminant concentrations in local groundwater exceed drinking water standards (arsenic, cadmium, iron, lead, manganese, antimony, zinc). The ARAR-based reclamation goals for groundwater are most often the MCLs, non-zero maximum contaminant level goals (MCLGs), or State HHSs, whichever are more stringent. Potential ARAR-based reclamation goals for the groundwater medium are presented in Table 6-1. Although direct groundwater treatment/remediation is not within the scope of actions under consideration at the site as part of this RI, removing source material will affect groundwater contaminant concentrations.

TABLE 6-1
ARAR-BASED RECLAMATION GOALS FOR GROUNDWATER

Contaminant of Concern	Federal Drinking Water MCL (μg/L)	State Groundwater HHS (μg/L)	Potential Groundwater ARAR (μg/L)
Antimony	6	6	6
Arsenic	50	20	20
Cadmium	5	5	5
Iron		300	300
Lead	15	15	15
Zinc		2,000	2,000

Sources: HHS - Human Health Standards for Surface Water (DEQ/WQB, 2002).
MCL – National Primary Drinking Water Standards (EPA, 2001)
μg/L – micrograms per Liter

6.1.2 Surface Water

Maximum Contaminant Levels, Acute Aquatic Life Standards (AALSs), and HHSs are common ARARs for the surface water medium. The more stringent of these standards is identified as the ARAR-based reclamation goal; acute rather than chronic aquatic life standards are appropriate since long-term monitoring data are not available to assess chronic exposure. The only contaminants that exceed surface water standards at the site are cadmium, lead, and zinc. Table 6-2 presents the ARAR-based reclamation goals for surface water.

TABLE 6-2
ARAR-BASED RECLAMATION GOALS FOR SURFACE WATER

Contaminant of Concern	State AALS (μg/L)	State HHS (μg/L)	Potential Surface Water ARAR (μg/L)
Cadmium	0.58 @ 28 mg/L Hardness	5	0.58
Lead	16.1 @ 28 mg/L Hardness	15	15
Zinc	40.7 @ 28 mg/L Hardness	2,000	40.7

***Source*:** AALS - Freshwater Acute Aquatic Life Standards (DEQ/WQB, 2002)
HHS - Human Health Standards for Surface Water (DEQ/WQB, 2002).
μg/L – micrograms per Liter
mg/L – milligrams per Liter

6.1.3 Soil

Chemical-specific ARARs are not available at this time for the soil medium.

6.2 RISK-BASED CLEAN UP GOALS

Previously calculated risk-based clean up goals for both the carcinogenic and non-carcinogenic estimates of human health risk are applied for two land-use scenarios at the Snowshoe Mine Site, recreational and residential. These concentrations were derived using exposure assumptions contained in other documents (Residential-Smith, 2002; Recreational-Tetra Tech, 1996) and are the same as those presented in Section 5.1. Both sets of clean up goals attempt to reduce the risk of excess incidence of cancer to 1.0E-06 (EPA, 1991) and the non-carcinogenic health hazard quotient (HQ) to <1.0 (EPA, 1989b). Both sets of clean up goals are presented in Table 6-3.

TABLE 6-3
PROPOSED CLEAN UP GOALS
FOR THE SNOWSHOE MINE SITE

Contaminant of Concern	Recreational Soil Ing./Inh. Waste Rock mg/kg	Recreational Water Ingestion µg/L	Residential Dust Inhalation mg/kg	Residential Soil Ingestion mg/kg	Residential Water Ingestion µg/L
Antimony	586	204	NA	31	15
Arsenic	323 1.4 (Carc.)	153 0.7 (Carc.)	740,000 380 (Carc.)	23 0.43 (Carc.)	11 0.045 (Carc.)
Cadmium	1,750 22 (Carc.)	256	140,000 920 (Carc.)	39	18
Lead	2,200	220	NA	400*	15*

NA = Not Applicable, concentration is more than unity.
* Used EPA recommendations, not RBC table from Smith, 2002.
mg/kg – milligrams per kilogram
µg/L – micrograms per Liter

Risk reduction required to attain non-carcinogenic human health and ecologic reclamation goals for each COC (by each pathway) is shown in Table 6-4.

TABLE 6-4
RISK REDUCTION NECESSARY TO ATTAIN NON-CARCINOGENIC HUMAN HEALTH AND ECOLOGIC CLEAN UP GOALS FOR THE SNOWSHOE MINE SITE

PATHWAY	RISK REDUCTION REQUIRED (%)				
	As	**Cd**	**Pb**	**Ag**	**Zn**
Human Health Exposure Pathways:					
Soil Ingestion (Res.)	99.2	92.8	99.4	--	--
Water Ingestion (Res.)	97.4	32.1	99.5	--	--
Soil Ing./Inh. (Recr.)	87.6	--	97.1	--	--
Water Ingestion (Recr.)	--	--	--	--	--
Ecological Exposure Pathways:					
Surface Water	--	90.3	22.4	75.4	88.3
Sediments	98.8	97.4	99.3	--	99.0
Plant Phytotoxicity	98.2	98.6	99.4	--	98.0

= Risk reduction not required for the contaminant for that pathway.

7.0 DEVELOPMENT AND SCREENING OF RECLAMATION ALTERNATIVES

The contaminated mine waste sources present at the Snowshoe Mine Site consist of four separate waste rock dumps and a large uncontained tailings pile. A portion of the largest waste rock dump (WR-4) and the tailings pile are situated directly in the floodplain of Snowshoe Creek.

The waste sources at the Snowshoe Mine Site can be categorized based upon their respective physical and chemical characteristics with applicable treatment options also dependent on the physical and chemical characteristics of each waste source. The waste sources can be summarized as follows:

- Three of the four waste rock dumps (WR-1, WR-2, and WR-3) are relatively small in terms of volume and aerial extent. Total volume and aerial extent of these waste rock dumps is approximately 3,100 cubic yards encompassing approximately 0.5 acre. These three small waste rock dumps are located high on an extremely steep slope on the south side of the site (approximately 500 vertical feet above Snowshoe Creek). WR-4 is a larger waste rock dump containing approximately 33,700 cubic yards of material and encompassing approximately 2.3 acres. A portion of WR-4 is located within the floodplain of Snowshoe Creek. The waste rock dumps consist of coarse mineralized soil and rock with elevated metals concentrations. According to laboratory results, WR-2, WR-3 and WR-4 are considered potential acid producers. Physical characteristics of the waste rock dumps range from sandy loam (USDA Texture Classification) to coarse rock (>50% 6-inch minus rock).

- The large, uncontained tailings deposit located at the site is situated directly within the floodplain of Snowshoe Creek. The deeper portion of the tailings is saturated with water. In fact, water is so abundant within the deeper portion of the tailings that it is speculated that the tailings may have been deposited directly in an alpine lake/pond. The portion of the tailings located on the south side of Snowshoe Creek has been designated as TP-1; the portion of the tailings located on the north side of Snowshoe Creek has been designated as TP-2. The total estimated volume of tailings is approximately 85,300 cubic yards encompassing approximately 7.3 acres. Physical characteristics of the tailings range from a sandy loam to a silt loam (USDA Texture Classification) with some coarse material intermixed (<50% 6 inch minus rock). Based on laboratory data, TP-1 and TP-2 are considered potential acid producers.

7.1 IDENTIFICATION OF RECLAMATION ALTERNATIVES

The purpose of identifying and screening reclamation alternatives is to eliminate those alternatives that are not feasible or practical while retaining the more practical and effective alternatives. In this section, general response actions and process options are evaluated for contaminated solid media only. No evaluation has been conducted for surface water, groundwater, or off-site stream sediments primarily because reclamation of the contaminated waste source will mitigate impacts to these other environmental media. General response actions potentially capable of meeting the reclamation objectives are identified in Table 7-1.

TABLE 7-1

GENERAL RESPONSE ACTIONS, TECHNOLOGY TYPES, AND PROCESS OPTIONS FOR CONTAMINATED SOLID MEDIA AT THE SNOWSHOE MINE SITE

General Response Action	Technology Type	Process Options
No Action	Not Applicable	Not Applicable
Institutional Controls	Access Restrictions	Fencing Land Use Control
Engineering Controls	Containment	Soil Cover Multimedia Cover Asphalt/Concrete Cover
	Surface Controls	Consolidation Grading Revegetation Erosion Protection Run-on/Run-off Control
	On-Site Disposal	Fully Encapsulated Repository Other Repository
	Off-Site Disposal	Hazardous Waste Landfill Solid Waste Landfill Permitted Tailings Facility
Excavation and Treatment	Fixation/Stabilization	Pozzolan/Cement Based
	Reprocessing	Milling/Smelting
	Physical/Chemical Treatment	Soil Washing Acid Extraction Alkaline Leaching
	Thermal Treatment	Fluidized Bed Reactor Rotary Kiln Multi-Hearth Kiln Vitrification
In-Situ Treatment	Physical/Chemical Treatment	Stabilization/Solidification Soil Flushing
	Thermal Treatment	Vitrification

7.1.1 No Action

Under the No Action Alternative, no future reclamation or monitoring would occur at the site. The No Action response is a stand-alone response that is used as a baseline against which candidate reclamation alternatives are compared.

7.1.2 Institutional Controls

Potentially applicable Institutional Controls consist of land use and access restrictions. Land use restrictions would limit the potential future uses for the land at the site. Limitations may be applicable in the case of No Action, on-site disposal, *in-situ* capping, or other reclamation alternatives that would result in leaving contaminated material on-site that could be compromised by land use activities (i.e., grazing, recreation, etc.).

Institutional Controls involve implementing access restrictions, such as fencing and land use control. These restrictions are implemented to preclude the future development of the impacted area or to protect an implemented remedy. This type of action does not achieve a specific clean-up goal; however, Institutional Controls will be considered as a way to augment other reclamation alternatives.

7.1.3 Engineering Controls

Engineering Controls are used primarily to reduce the mobility of contaminants by creating a barrier that prevents transport of waste from the contaminant source to the surrounding environment. Engineering Controls do not actually reduce the volume or toxicity of the contaminated material. Engineering Controls may include containment/capping, revegetation, run-on/runoff controls, and/or disposal. The following subsections describe Engineering Controls in more detail.

7.1.3.1 Containment/Capping

Containment technologies are used as source control measures to divert surface water from the contaminated media and to minimize infiltration (and subsequent formation of leachate) of surface water/precipitation into the underlying contaminated media. By isolating a waste source, potential health risks that may be associated with exposure (direct contact or airborne releases of particulates) to the contaminated media are reduced. The bottom liner, cap or cover design is a function of the degree of hazard posed by the contaminated media and may vary in complexity from a simple soil cover to a fully constructed repository with a bottom liner and leachate collection system and multi-layered cap. Repository or cap design criteria are driven by risk evaluation and the desired land use following construction.

Repository construction and capping are considered standard construction practices. Equipment and construction methods are readily available and design methods and requirements are well understood.

7.1.3.2 Surface Controls

Similar to containment, surface control measures are used primarily to reduce contaminant mobility. Surface controls may be appropriate in more remote areas where direct human contact is not a primary concern (human receptors not living or working directly on or near the site). Surface control options are directed at controlling water and wind impacts on contaminated materials. Options include consolidation, grading, revegetation, and erosion protection. These options are often integrated as a single reclamation alternative.

Consolidation involves grouping similar waste types in a common area for subsequent management or treatment. Consolidation is especially applicable when multiple waste sources are present at a site and one or more of the sources require removal from particularly sensitive areas (e.g., floodplain, residential area, or heavy traffic area) or when treating one large combined waste source in a particular location is more cost effective than treating several smaller waste sources dispersed throughout an area.

Grading is the general term for techniques used to reshape the ground surface to reduce slopes, to manage surface water infiltration and runoff, and to aid in erosion control. The spreading and compaction steps used in grading are routine construction practices. The equipment and methods used in grading are similar for all surfaces, but will vary slightly depending upon the waste type and the surrounding terrain. Periodic maintenance and regrading may be necessary to eliminate depressions formed as a result of settlement/subsidence or erosion.

Revegetation involves adding soil amendments as necessary to the waste's surface to provide nutrients, organic material, and neutralizing agents and/or to improve the water holding capacity of the contaminated media, as necessary. This action establishes native vegetative species to provide an erosion-resistant ground surface that helps prevent wind-blown contaminants and reduces net infiltration through the contaminated media by increasing the evapotranspiration processes. In general, revegetation includes the following steps: 1) selecting appropriate plant species; 2) preparing the seedbed, which may include deep application of soil amendments as necessary; 3) seeding/planting; 4) mulching and/or chemical stabilization; and 5) fertilizing and maintenance.

Erosion protection includes using erosion resistant materials, such as mulch, natural or synthetic fabric mats, riprap, and/or surface water diversion ditches, to reduce the erosion potential at the contaminated media's surface. The erosion resistant materials are placed in areas susceptible to surface water erosion (concentrated flow or overland flow) or wind erosion. Proper erosion protection design requires knowledge of drainage area characteristics, slope steepness, soil texture, vegetation types and abundance, and precipitation patterns.

7.1.3.3 Off-Site Disposal

Off-site disposal involves placing contaminated material in an engineered containment facility located outside the site boundary. Off-site disposal options may be applied to pretreated or untreated contaminated materials and would depend on TCLP results. Materials failing to meet TCLP criteria would require disposal in an approved Treatment, Storage, and Disposal (TSD) facility. Conversely, less toxic materials could possibly be disposed in an approved off-site sanitary landfill or mine waste landfill.

7.1.3.4 Excavation and Treatment

Excavation and treatment involves the removal of contaminated media and subsequent treatment via a specific treatment process that chemically, physically, or thermally results in a reduction of contaminant toxicity and/or volume. Treatment processes have the primary objective of: 1) concentrating the metal contaminants for additional treatment or recovery of valuable constituents; or 2) reducing the toxicity of the hazardous constituents.

Excavation can be completed using conventional earth-moving equipment and accepted hazardous materials handling procedures. Precautionary measures, such as temporary stream diversion or isolation, may be necessary for excavating materials contained in the floodplain of a stream. Pumping, containment, and/or treatment of water encountered during excavation may also be necessary.

7.1.3.5 Fixation/Stabilization

Fixation/stabilization technologies are used to treat materials by physically encapsulating them in an inert matrix (stabilization) and/or chemically altering them to reduce the mobility and/or toxicity of the contaminants (fixation). These technologies generally involve mixing materials with binding agents under prescribed conditions to form a stable matrix. Fixation/stabilization is an established technology for treating inorganic contaminants. The technology incorporates a reagent or combination of reagents to facilitate a chemical and/or physical reduction of the mobility of contaminants in the solid media. Lime/fly ash-based treatment processes and pozzolan/cement-based treatment processes are potentially applicable fixation/stabilization technologies.

7.1.3.6 Reprocessing

Reprocessing involves excavating and transporting the waste materials to an existing permitted mill or smelter facility for processing and economic recovery of target metals. Applicability of this option depends on the willingness of an existing permitted facility to accept and process the material and dispose of the waste by-products. Although reprocessing at active facilities has been conducted in the past, permit limitations, CERCLA liability, and process constraints all limit the feasibility of this option.

7.1.3.7 Physical/Chemical Treatment

Physical treatment processes use physical characteristics to concentrate contaminants into a relatively small volume for disposal or further treatment. Chemical treatment processes treat contaminants through adding a chemical reagent that removes or immobilizes the contaminants. The net result of chemical treatment processes is a reduction of toxicity and/or mobility of contaminants in the solid media. Chemical treatment processes often work in conjunction with physical processes to wash the contaminated media with water, acids, bases, or surfactants. Potentially applicable physical/chemical treatment process options include soil washing, acid extraction, and alkaline leaching.

Soil washing is an innovative treatment process that consists of washing the contaminated media with water in a heap, vat, or agitated vessel to dissolve water-soluble contaminants. Soil washing requires that contaminants be readily soluble in water and consist of small enough particles so that dissolution can be achieved in a practical retention time. Dissolved metals contained in the wash solution are precipitated as insoluble compounds, and the treated solids are dewatered before additional treatment or disposal. The precipitates form a sludge that would require additional treatment, such as dewatering or stabilization before disposal.

Acid extraction applies an acidic solution to the contaminated media in a heap, vat, or agitated vessel. Depending on temperature, pressure, and acid concentration, varying quantities of the metals present in the contaminated media would be solubilized. A broader range of contaminants can be expected to be acid soluble at ambient conditions using acid extraction versus soil washing; however, sulfide compounds may only be acid soluble under extreme conditions of temperature and pressure. Dissolved contaminants are subsequently precipitated for additional treatment and/or disposal.

Alkaline leaching is similar to acid extraction in that a leaching solution (ammonia, lime, or caustic soda) is applied to the contaminated media in a heap, vat, or agitated vessel. Alkaline leaching is potentially effective for leaching the majority of metals from the contaminated media; however, the removal of arsenic is problematic.

7.1.3.8 Thermal Treatment

Under thermal treatment technologies, heat is applied to the contaminated media to volatilize and oxidize metals and render them amenable to additional processing and/or to vitrify the contaminated media into a glass-like, non-toxic, non-leachable matrix. Potentially applicable moderate temperature thermal processes, which volatilize metals and form metallic oxide particulates, include the fluidized bed reactor, the rotary kiln, and the multi-hearth kiln. Potentially applicable high temperature thermal treatment processes include vitrification. All components of the contaminated media are melted and/or volatilized under high temperature vitrification. Volatile contaminants and gaseous oxides of sulfur are driven off as gases in the process and the non-volatile molten material containing contaminants is cooled and, in the process, vitrified.

Thermal treatment technologies can be applied to wet or dry contaminated media; however, the effectiveness may vary somewhat with variable moisture content and particle size. Crushing may be necessary as a pre-treatment step, especially for large and/or variable particle sizes, such as in waste rock dumps. Moderate temperature thermal processes should only be considered as pretreatment for other treatment options. This process concentrates the contaminants into a highly mobile (and potentially more toxic) form. High temperature thermal processes immobilize most metal contaminants into a vitrified slag that would have to be properly disposed. The volatile metals would be removed and/or concentrated into particulate metal oxides that would likely require disposal as hazardous waste. Thermal treatment costs are extremely high compared to other potentially applicable reclamation technologies.

7.2 RECLAMATION TECHNOLOGY SCREENING FOR THE SNOWSHOE MINE SITE

Because certain treatment technologies discussed in Section 7.1 are cost-prohibitive, ineffective, or not feasible to implement at the Snowshoe Mine Site, some of the technologies have been eliminated from consideration. Table 7-2 summarizes each treatment option discussed in Section 7.1 and provides rationale for eliminating certain options.

TABLE 7-2

REMEDIAL TECHNOLOGY SCREENING SUMMARY – SNOWSHOE MINE SITE

GENERAL RESPONSE ACTIONS	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	DESCRIPTION	SCREENING COMMENT
NO ACTION	None	Not Applicable	No Action	
INSTITUTIONAL CONTROLS	Access Restrictions	Fencing	Security fences installed around contaminated areas to limit access.	Potentially effective in conjunction with other technologies. Readily implementable.
		Land Use Control	Restrictions to control current and future land use.	Potentially effective in conjunction with other process options. Readily implementable.
ENGINEERING CONTROLS	Containment	Soil Cover	Application of soil and establishment of vegetative cover to stabilize surface of contamination source.	Surface infiltration and runoff potential would be reduced, but not prevented. Readily implementable.
		Multilayered Cap	Compacted clay or synthetic membrane covered with soil/vegetation over areas of surface contamination.	Potentially effective for some waste sources in conjunction with regrading. Readily implementable.
		Asphalt/Concrete Cover	Application of layer of asphalt or concrete over areas of surface contamination.	Limited feasibility due to remoteness of area and steep slopes. Would require extensive grading and compaction.
		Wet Closure	Applicable to wet tailings. Construct dam to flood tailings with water and provide anaerobic environment to limit oxidation/migration of contaminants.	Potentially effective if adequate coverage is provided during dry conditions. A liner would likely be required for adequate containment. Potentially implementable, but in general, not widely accepted as a viable option.
	Surface Controls	Consolidation	Combining similar waste types in a common area.	Potentially effective in conjunction with other process options. Involves removing wastes from particularly sensitive areas (e.g. floodplain). Readily implementable.
		Grading	Level out waste piles to reduce slopes for managing surface water infiltration, runoff, and erosion.	Potentially effective in conjunction with other process options. Readily implementable.
		Revegetation	Adding amendments to waste and seeding with appropriate vegetative species to establish an erosion resistant ground surface.	Potentially effective in arid climates if waste does not contain high concentrations of phytotoxic contaminants. Readily implementable.
		Erosion Protection/Run-on Control	Erosion resistant materials/fabrics placed directly on waste sources to reduce surface erosion. Surface water diversion structures constructed to direct runoff away from waste source(s).	Potentially effective at reducing contaminant mobility. Readily implementable.
	On-site Disposal	Engineered Repository	Excavated contaminated soil deposited on-site in an engineered repository.	Potentially effective and readily implementable. Depends on site-specific groundwater characteristics (i.e., depth to groundwater).

TABLE 7-2 (Cont'd)

REMEDIAL TECHNOLOGY SCREENING SUMMARY – SNOWSHOE MINE SITE

GENERAL RESPONSE ACTIONS	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	DESCRIPTION	SCREENING COMMENT
		Sanitary Landfill	Excavated contaminated soil deposited on-site in sanitary landfill.	Potentially effective for non-hazardous materials or non-hazardous residues from other treatment process options. Readily implementable.
	Off-site Disposal	Permitted Landfill	Wastes permanently disposed of in a permitted facility.	Potentially effective and implementable, but generally cost prohibitive due to high disposal costs in conjunction with significant transportation costs.
		Permitted Tailings Disposal Facility	Depositing tailings in a permitted off-site impoundment.	Potentially effective if facility with adequate capacity is willing to accept waste. Potentially implementable, but cost-prohibitive due to liability considerations.
EXCAVATION AND TREATMENT	Fixation/Stabilization	Pozzolan/Cement Based	Hazardous constituents are incorporated into non-leachable cement or pozzolan solidifying agents.	Extensive treatability testing required. Proper disposal of stabilized product would be required. Potentially implementable, but cost-prohibitive.
	Reprocessing	Milling/Smelter	Shipping wastes to existing milling/smelter facility for economic extraction of metals.	Potentially effective if a facility is located and willing to accept waste. Potentially implementable, but cost-prohibitive due to liability considerations.
	Physical/Chemical Treatment	Soil Washing	Separate hazardous constituents from solid media via dissolution and subsequent precipitation.	Effectiveness is questionable. Potential exists to increase mobility by providing partial dissolution of contaminants. More difficulty encountered with wider range of contaminants.
		Acid Extraction	Mobilize hazardous constituents via acid leaching and recover by subsequent precipitation.	Effectiveness is questionable. Sulfides would be acid soluble only under extreme conditions of temperature and pressure.
		Alkaline Leaching	Use alkaline solution to leach contaminants from solid media in a heap, vat, or agitated vessel.	Effectiveness not well-documented for arsenic. Problems associated with disposal of contaminated sludge and leachate solution.
	Thermal Treatment	Fluidized Bed Reactor/Rotary Kiln/Multi-Hearth Kiln	Concentrate hazardous constituents into a small volume by volatilization of metals and formation of metallic oxides as particulates.	Further treatment is required to treat process by-products. Potentially implementable, but cost-prohibitive.
		Vitrification	Extremely high temperature used to melt and/or volatilize all components of the solid media. The molten material containing contaminants is cooled and, in the process, vitrified into a non-leachable form.	Further treatment is required to treat process by-products. Potentially implementable, but cost-prohibitive.

TABLE 7-2 (Cont'd)

REMEDIAL TECHNOLOGY SCREENING SUMMARY – SNOWSHOE MINE SITE

GENERAL RESPONSE ACTIONS	REMEDIAL TECHNOLOGY	PROCESS OPTIONS	DESCRIPTION	SCREENING COMMENT
IN SITU TREATMENT	Physical/Chemical Treatment	Stabilization	Waste constituents stabilized in place when combined with injected stabilizing agents.	Extensive treatability testing required. Potentially implementable, but cost-prohibitive.
		Solidification	Solidifying agents used in conjunction with deep soil mixing techniques to facilitate a physical or chemical change in mobility of the contaminants.	Extensive treatability testing required. Potentially implementable, but cost-prohibitive.
		Soil Flushing	Acid/base reagent or chelating agent injected into solid media to solubilize metals. Solubilized reagents are subsequently extracted using dewatering techniques.	Effectiveness not certain. Innovative process currently in its pilot stage.
	Thermal Treatment	Vitrification	Contaminated solid media subjected to extremely high temperature in-place. During cooling, material is vitrified into non-leachable form.	Expect difficulties to be encountered in establishing adequate process control. Potentially implementable, but cost-prohibitive.

Legend

- Technologies/Process options that are screened out.

7.3 SITE-SPECIFIC ALTERNATIVES

In this section, the reclamation technology types and associated treatment options that passed the initial screening as discussed in Sections 7.1 and 7.2 are presented as reclamation alternatives applicable to the Snowshoe Mine Site. Table 7-3 presents the reclamation alternatives that have been identified for consideration at the Snowshoe Mine Site.

TABLE 7-3
RECLAMATION ALTERNATIVES
APPLICABLE TO THE SNOWSHOE MINE SITE

ALTERNATIVE	ACTION
Alternative 1	No Action
Alternative 2	Institutional Controls
Alternative 3a	In-Place Containment of Select Waste Sources
Alternative 3b	In-Place Containment of All Waste Sources
Alternative 4a	Removal/Disposal of Tailings in a Constructed Repository and In-Place Containment of WR-4
Alternative 4b	Removal/Disposal of Select Waste Sources in a Constructed Repository and In-Place Containment of Remaining Waste Sources
Alternative 5	Removal/Disposal of All Waste Sources in an Off-Site Disposal Facility

Active treatment of the surface water at the Snowshoe Mine Site (Snowshoe Creek) is not considered because it is assumed that proper reclamation of the on-site mine waste sources would improve surface water quality. For this EEE/CA, only reclamation alternatives applicable to solid media are developed and evaluated in detail.

7.4 PRELIMINARY EVALUATION AND SCREENING OF ALTERNATIVES

In this section, the alternatives identified in Section 7.3 are described, developed, and then subjected to a preliminary evaluation and screening process. The evaluation and screening process is based on the anticipated effectiveness, implementability, and costs for each alternative. A preliminary screening has been conducted to identify those alternatives that are not as cost-effective or implementable as other alternatives or would not provide a similar degree of risk reduction.

The evaluation of effectiveness includes determining the ability of an alternative to effectively reduce adverse human health or environmental impacts sufficiently to achieve the reclamation goals. The reclamation goals include overall protection of human health and the environment, compliance with ARARs, and short- and long-term effectiveness and/or performance related to reducing toxicity, mobility, and/or volume of contaminants. The effectiveness screening criteria includes consideration of the nature and extent of the contamination, as well as site-specific conditions, such as geology, hydrology, hydrogeology, climate, current land use, and potential future land use.

The implementability of each alternative is evaluated to consider the technical and administrative feasibility of constructing, operating, and maintaining each reclamation alternative. Technical feasibility considerations include applicability of the alternative to the waste source(s), availability of the required equipment, expertise to execute the alternatives, and overall reliability of the alternative. Administrative feasibility considerations include logistical and scheduling constraints. The evaluation of implementability also considers appropriate combinations of alternatives with respect to site-specific conditions.

Cost screening consists of developing conservative, order-of-magnitude cost estimates for each reclamation alternative based on a similar set of assumptions. Costs have been developed from data associated with similar reclamation projects conducted by the DEQ/MWCB at other abandoned mines. Unit and total costs presented in the cost evaluations are structured to account for contaminated materials handling, adverse site conditions, and contingencies.

It has been assumed that 12 inches of soil underlying each waste source is contaminated and would require removal under Alternatives 4a, 4b, and 5. Cost estimates are based on the estimated volume of waste rock, tailings material, and underlying contaminated soil as summarized in Table 7-4.

TABLE 7-4

**WASTE SOURCE QUANTITIES SUMMARY
SNOWSHOE MINE SITE**

Waste Source	Surface Area (acres)	Volume Estimate (cubic yards)	Volume Estimate + 12 inches (cubic yards)
WR-1	0.35	2,500	3,100
WR-2	0.10	450	600
WR-3	0.05	200	300
WR-4	2.3	33,700	37,500
TP-1, TP-2	7.30	85,300	97,000
TOTAL	**10.10***	**122,150**	**138,500**

*Includes portion of TP-1 and TP-2 that is on Kootenai National Forest land
cy – cubic yards

A screening summary is presented after evaluating each alternative to identify alternatives retained for further detailed evaluation and to offer rationale for those alternatives that will not be considered for further detailed analysis.

7.4.1 Alternative 1: No Action

The No Action Alternative means that no actual reclamation activities would occur at the Snowshoe Mine Site to control contaminant migration or to reduce toxicity or volume of the wastes.

Effectiveness - Protection of human health and the environment would not be achieved under the No Action Alternative. Prevention of direct human contact would also not be achieved. No Action continues to provide a pathway to affect human health through direct contact. Toxicity, mobility, and volume of contaminants would not be reduced under the No Action Alternative.

Implementability - Technical and administrative feasibility evaluation criteria do not apply to this alternative.

Cost Screening - No capital or operating costs would be incurred under this alternative.

Screening Summary - This alternative has been retained for further evaluation in accordance with the NCP.

7.4.2 Alternative 2: Institutional Controls

Alternative 2 includes erecting fences around the waste sources to restrict access to the mine waste materials and implementing land use restrictions to prevent land development on or near the affected areas. Local government agencies would be required to implement and enforce any Institutional Controls that are implemented.

Effectiveness - Alternative 2 is not protective of important environmental resources. It is not fully protective of human health if implemented as a stand-alone alternative because toxicity, mobility, and volume of the contaminated media would not be reduced. Contaminants would continue to be mobilized via wind and surface water erosion.

Implementability - Institutional Controls are potentially implementable based on the criteria of applicability, availability, and reliability. Alternative 2 is considered applicable for minimizing the potential for direct contact and restricting future land development. Fencing materials and construction contractors are readily available. Reliability of this alternative for its intended purpose (protection from direct contact) is considered inadequate due to the level of recreational use of the general area. Because of the unlikelihood of implementing Institutional Controls, administrative feasibility is also considered unfavorable.

Cost Screening - Costs associated with Institutional Controls such as fencing would be relatively low compared to other reclamation measures. Capital costs associated with construction of an 8-foot tall, chain-link fence would be approximately $108,000 (assuming 7,200 lineal feet at $15.00 per foot). Maintenance costs are estimated to be less than $1,000 per year.

Screening Summary - Alternative 2 will not be considered further as a stand-alone remedial alternative but may be used in conjunction with other selected treatment alternatives.

7.4.3 Alternative 3a: In-Place Containment of Select Waste Sources

Alternative 3a involves in-place containment of select waste sources at the site. Under this alternative, WR-4, TP-1, and TP-2 would be recontoured, amended with lime, covered with a suitable vegetative cover, and seeded with an appropriate seed mix. The purpose of establishing vegetation is to stabilize the surface (provide erosion protection) and to decrease net infiltration, through evapotranspiration, into the underlying waste material. No action would be taken at WR-1, WR-2, and WR-3 due to accessability issues (the expense associated with building a sufficient road to provide access to WR-1, WR-2, and WR-3 may not be worth the benefit of reclaiming these small sources); however, the two open adits in the vicinity of the upper waste rock dumps would be closed using bat-friendly grates. Cover soil will be derived from the Site B-1 Repository/Borrow Area as described in Section 3.1.4.3.

Based on available site data and the above considerations, the conceptual design for Alternative 3a includes:

- Upgrade the Bear Creek Road (FR 278), as necessary, from Highway 2 to the borrow area. Upgrade FR 867 from the borrow area to the intersection with FR 6213, as necessary. FR 6213 from FR 867 to the Snowshoe Mine Site, would require significant upgrades (including widening and construction of turnouts) to facilitate safe access by construction crews and equipment.

- Install temporary construction bridge cross Snowshoe Creek.

- Implement construction Best Management Practices (BMPs) to protect surface water resources during site reclamation activities.

- Develop (clear and grub, salvage topsoil, etc.) and reclaim the borrow area.

- Recontour and amend TP-1, TP-2, and WR-4 with lime, place cover soil to a depth of 12 inches, and revegetate all disturbed areas upon completion of the construction activities (temporary roads, staging areas, cover soil application areas, etc.).

- Install erosion control mat over WR-4.

- Hard armor eastern perimeter of WR-4 in area of intermittent drainage.

- Install bat-friendly adit closures at two open adits located in the vicinity of the upper waste rock dumps.

- Install diversion ditches to facilitate run-on/runoff controls around the perimeter of TP-1, TP-2, and WR-4.

- Install 4-strand barbed wire fences surrounding reclaimed areas.

Access to Libby is adequate to transport crews, equipment, and materials to the site. Some portions of the Bear Creek Road (FR 278) and FR 867 may require minor upgrades to accommodate heavy equipment. FR 6213, from the borrow area to the Snowshoe Mine Site would require significant upgrades (approximately 3 miles).

The proposed cover soil source is located approximately 3 miles east of the mine site (Site B-1). Based on analytical results from the repository site investigation, the cover soil contains very little organic matter (1 to 3%), is nutrient-poor, and would require fertilizer application and amendment with organic matter to establish a suitable plant growth medium.

Seeding would likely take place during the fall of the year. The seed mixture and fertilizer would be applied simultaneously to the prepared seedbeds via drill application. Mulch would be applied to promote temporary protection of the disturbed surfaces. Straw mulch (certified weed-free) would be applied over the reclaimed materials with a tow spreader or pneumatic spreader utilizing tucking/crimping as the anchoring mechanism.

Run-on/runoff control would be achieved by construction of necessary diversion structures. Temporary surface water diversions (e.g., culvert, pipe, lined ditch, etc.) may need to be constructed to control storm water and BMPs would be implemented to prevent runoff and sedimentation into Snowshoe Creek during construction activities.

Effectiveness - The primary purpose of establishing vegetation on contaminated solid media through in-place containment is to minimize human and terrestrial biota exposure to the contaminants via direct contact and inhalation of entrained dust. In addition, establishing vegetation would limit the contaminant's mobility. Vegetation effectively stabilizes the surface against wind and surface water erosion, and minimizes the potential for migration of vadose zone contaminants from water infiltration by increasing evapotranspiration and decreasing infiltration. The toxicity and volume of the wastes would not be reduced under this alternative since no actual treatment of the contaminants would occur. The overall effectiveness of the containment/revegetation program would be enhanced by carefully selecting appropriate plant species that are metal tolerant and adapted to relatively high altitudes and relatively short growing seasons. Since TP-1 and TP-2 are located directly within the floodplain of Snowshoe Creek, there is no assurance that future erosion of these waste sources from significant precipitation events would not occur if they are contained in-place.

Implementability - This alternative is both technically and administratively feasible. Incorporation of amendments, soil covers, and establishing vegetation are readily implementable technologies that use conventional construction techniques. Design methods and requirements have been thoroughly tested and the necessary construction equipment and methods are readily available and widely used. Construction methods may vary depending on the complexity of the terrain and the required depth of amendment incorporation.

Cost Screening - The total capital cost for Alternative 3a has been estimated at $652,586. Cost estimate details are included in Table D-1 (Appendix D).

The following assumptions were used to calculate costs for this alternative:

- Recontour WR-4 to a 3:1 configuration (2.9 acres). Recontour TP-1 and TP-2 for drainage control (7.3 acres).

- An estimated 16,500 cubic yards of cover soil is required to cover WR-4, TP-1, and TP-2 to a depth of 12 inches. Excavation and subsequent set aside of topsoil to reclaim the borrow area is estimated at 4,120 cubic yards.

- The total surface area at the Snowshoe Mine Site requiring revegetation under this alternative is approximately 10.1 acres, plus approximately 2.5 acres for the borrow area.

- Approximately 2,000 lineal feet of run-on/runoff control ditches would be required to protect the reclaimed waste sources.

Screening Summary – Under this alternative, the tailings material would remain in direct contact with Snowshoe Creek as well as in direct contact with the groundwater that recharges Snowshoe Creek. Additionally, due to their location, waste materials may continue to erode into the creek during high runoff events. The long-term effectiveness of this alternative is questionable; therefore, Alternative 3a will not be retained for detailed analysis.

7.4.4 Alternative 3b: In-Place Containment of All Waste Sources

Alternative 3b involves in-place containment of all waste sources at the site (including the upper waste rock dumps, where providing access for the necessary construction equipment would be challenging and expensive). Under this alternative, the waste sources would be recontoured, amended with lime, covered with a suitable vegetative cover, and seeded with an appropriate seed mix. Additionally, the two open adits in the vicinity of the upper waste rock dumps would be closed using bat-friendly grates. The purpose of establishing vegetation is to stabilize the surface (provide erosion protection) and to decrease net infiltration, through evapotranspiration, into the underlying waste material. Cover soil will be derived from the Site B-1 Repository/Borrow Area as described in Section 3.1.4.3.

Based on available site data and the above considerations, the conceptual design for Alternative 3b includes:

- Upgrade the Bear Creek Road (FR 278), as necessary, from Highway 2 to the borrow area. Upgrade FR 867 from the borrow area to the intersection with FR 6213, as necessary. FR 6213 from FR 867 to the Snowshoe Mine Site, would require significant upgrades (including widening and construction of turnouts) to facilitate safe access by construction crews and equipment.

- Install temporary construction bridge cross Snowshoe Creek.

- Construct access road to the upper waste rock dumps.

- Implement construction BMPs to protect surface water resources during site reclamation activities.

- Develop (clear and grub, salvage topsoil, etc.) and reclaim the borrow area.

- Recontour and amend the waste sources with lime, place cover soil to a depth of 12 inches, and revegetate all disturbed areas upon completion of the construction activities (temporary roads, staging areas, cover soil application areas, etc.).

- Install erosion control mat over all waste rock dumps.

- Hard armor eastern perimeter of WR-4 in area of intermittent drainage.

- Install bat-friendly adit closures at two open adits located in the vicinity of the upper waste rock dumps.

- Install diversion ditches to facilitate run-on/runoff control around the perimeter of the reclaimed sources.

- Obliterate and reclaim the newly constructed access road to the upper waste rock dumps.

- Install 4-strand barbed wire fences surrounding the reclaimed areas.

Access to the site from Libby is adequate to transport crews, equipment, and materials to the site. Some portions of the Bear Creek Road (FR 278) and FR 867 may require minor upgrades to accommodate heavy equipment. FR 6213, from the borrow area to the Snowshoe Mine Site, would require significant upgrades (approximately 3 miles). Under this alternative, a new road would need to be constructed to allow access to the upper waste rock dumps. Due to the extremely steep topography of the area, the road would include several switchbacks and would need to be approximately 5,000 feet in total length to provide a suitable grade for construction equipment. Construction of this road would be a major endeavor and would require a large investment in both time and capital under this alternative.

The proposed cover soil source is located approximately 3 miles east of the mine site (Site B-1). Based on analytical results from the repository site investigation, the cover soil contains very little organic matter (1 to 3%), is nutrient-poor, and would require fertilizer application and amendment with organic matter to establish a suitable plant growth medium.

Seeding would likely take place during the fall of the year. The seed mixture and fertilizer would be applied simultaneously to the prepared seedbeds via drill application. Seeding of the extremely steep upper waste rock dumps would be completed via broadcast or hydraulic methods. Mulch would be applied to promote temporary protection of the disturbed surfaces. Straw mulch (certified weed-free) would be applied over the reclaimed materials with a tow spreader or pneumatic spreader utilizing tucking/crimping as the anchoring mechanism.

Run-on/runoff controls would be achieved by construction of necessary diversion structures. Temporary surface water diversions (i.e., culvert, pipe, lined ditch, etc.) may need to be constructed to control storm water and BMPs would be implemented to prevent runoff and sedimentation into Snowshoe Creek during construction activities.

Effectiveness – The primary purpose of establishing vegetation on contaminated solid media through in-place containment is to minimize human and terrestrial biota exposure to the contaminants via direct contact and inhalation of entrained dust. In addition, establishing vegetation would limit the contaminant's mobility. Vegetation effectively stabilizes the surface against wind and surface water erosion, and minimizes the potential for migration of vadose zone contaminants from water infiltration by increasing evapotranspiration and decreasing infiltration. The toxicity and volume of the wastes would not be reduced under this alternative since no actual treatment of the contaminants would occur. The overall effectiveness of the containment/revegetation program would be enhanced by carefully selecting appropriate plant species that are metal tolerant and adapted to relatively high altitudes and relatively short growing seasons. Since TP-1 and TP-2 are located directly within the floodplain of Snowshoe Creek, there is no assurance that future erosion of these waste sources from significant precipitation events would not occur if they are contained in-place.

Implementability – This alternative is both technically and administratively feasible; however, construction of a road capable of providing safe access for the required equipment to the upper waste rock dumps would be challenging and time consuming. Incorporation of amendments, soil covers, and establishing vegetation are readily implementable technologies that use conventional construction techniques. Design methods and requirements have been thoroughly tested and the necessary construction equipment and methods are readily available and widely used. Construction methods may vary depending on the complexity of the terrain and the required depth of amendment incorporation.

Cost Screening - The total capital cost for Alternative 3b has been estimated at $888,355. Cost estimate details are included in Table D-2 (Appendix D).

The following assumptions were used to calculate costs for this alternative:

- Recontour WR-4 to a 3:1 configuration (2.9 acres). Recontour TP-1 and TP-2 for drainage control (7.3 acres).

- The access road to the upper waste rock dumps would be approximately 4,900 lineal feet and would include insloping and construction of a safety berm in compliance with Mine Safety and Health Administration (MSHA) regulations.

- An estimated 17,500 cubic yards of vegetative cover is required to cover WR-1, WR-2, WR-3, WR-4, TP-1, and TP-2 to a depth of 12 inches. Excavation and subsequent set aside of topsoil to reclaim the borrow area is estimated at 4,360 cubic yards.

- The total surface area at the Snowshoe Mine Site requiring revegetation under this alternative is approximately 14.3 acres, plus approximately 2.7 acres for the borrow area.

- Approximately 2,500 lineal feet of run-on/runoff control ditches would be required to protect the reclaimed waste sources.

Screening Summary - Under this alternative, the tailings material would remain in direct contact with Snowshoe Creek as well as in direct contact with the groundwater that recharges Snowshoe Creek. Additionally, due to their location, waste materials may continue to erode into the creek during high runoff events. The long-term effectiveness of this alternative is questionable; therefore, Alternative 3a will not be retained for detailed analysis.

7.4.5 Alternative 4 - Repository Design Options

Three repository design options are evaluated under Alternative 4. The major difference between the three options includes the materials used in the design of the bottom liner system and the design of the cap. The three options considered include: 1) repository consisting of a cover soil cap; 2) repository consisting of a multi-layered (impermeable) cap; and 3) repository consisting of a composite bottom liner with an integral leachate collection and removal system, also with a multi-layered cap (see Figures 7-1, 7-2, and 7-3).

Design and construction costs associated with the three options will vary according to the relative degree of protection provided by the repository design (i.e., the higher the relative degree of protection provided by the liner system, the higher the associated costs). Although costs have been developed for each of these options, only one of the options (Scenario #2, construction of a repository with a multi-layered cap) is evaluated under Alternatives 4a and 4b (Alternative 4a includes disposal of only the tailings in the repository; Alternative 4b includes disposal of the tailings and WR-4 in the repository). Evaluating each repository design option independently would be overly redundant because the only significant differences in the evaluation of each option would include the estimated cost and the relative risk reduction. The costs associated with each scenario are included in the cost section.

The proposed location for the repository (Site B-1, as described in Section 3.1.4.3) is currently heavily forested. Although the timber in the repository area would be cleared prior to constructing the repository, future invasion by trees on the repository cap may occur. Grasses, forbs and shrubs are the desirable vegetation types for cover systems due to shallow rooting characteristics that do not reach the barrier layers of the cover system. Consequently, routine maintenance, in the form of tree removal from the repository cap, is suggested if Alternative 4a or 4b is implemented at the Snowshoe Mine Site.

Geomembrane liners (polyvinyl chloride [PVC] or high density polyethylene [HDPE]) are capable of resisting tree root penetration in constructed caps, mostly due to the fact that the seams between adjacent panels of the geomembrane are continuously heat-welded. Geosynthetic clay liner (GCL) is the most popular liner material used on past abandoned mine site reclamation projects due to ease of installation and no requirements for special installation skills; however, GCL is not as capable of resisting tree root penetration in constructed caps. Seams between adjacent panels of GCL are overlapped (not continuously welded) and roots from deep rooting trees could gain access to the underlying waste materials between the overlaps. In the event that a tree reaches maturity on the repository cap and eventually topples, the resulting upturned root mass is less likely to expose underlying mine waste materials if the repository cap is constructed using a geomembrane liner as opposed to GCL. Due to this concern, the reclamation alternatives for the Snowshoe Mine Site involving construction of a repository to contain the mine wastes assume that the repository would be constructed using PVC geomembrane liner materials.

7.4.6 Alternative 4a: Removal/Disposal of Tailings in a Constructed Repository and In-Place Containment of WR-4

Alternative 4a involves removal and disposal of selected waste materials in a constructed repository. Under this alternative, the tailings material (TP-1 and TP-2, comprising approximately 97,000 cubic yards of material) would be completely excavated and disposed in the repository, WR-4 would be contained in-place, and no action would be taken for the upper waste rock dumps (WR-1, WR-2, and WR-3); however, the two open adits in the vicinity of the upper waste rock dumps would be closed using bat-friendly grates. The repository would be constructed at Site B-1 and would consist of a multi-layered cap with no bottom liner system.

Excavation of the tailings would require temporary diversion of Snowshoe Creek and would involve extensive dewatering of the excavation area. Following removal of the tailings, the resulting excavated footprint would be covered with a minimum of 12 inches of cover soil followed by revegetation. Removal of the tailings would also result in complete elimination of the existing streambed, channel and floodplain of Snowshoe Creek; consequently, Snowshoe Creek would need to be reconstructed along its original (pre-mining) alignment. Alternatively, depending on the site conditions following excavation of the tailings, an alpine lake/pond could possibly be constructed in the tailings excavation area.

WR-4 would be contained in-place by grading, amending with lime (as necessary), covering with a minimum of 12 inches of cover soil, and revegetating. Due to the steepness of the lower (northern) portion of WR-4, this section of the dump would also be covered with erosion control mat. Additionally, the eastern edge of WR-4 located in close proximity to the intermittent drainage, would be armored with riprap.

The purpose of establishing vegetation is to stabilize the surface (provide erosion protection) and to decrease net infiltration, through evapotranspiration, into the underlying waste material. Cover soil would be derived from the Site B-1 Repository/Borrow Area as described in Section 3.1.4.3.

Based on the available data and the above considerations, the conceptual design for Alternative 4a includes:

- Upgrade the Bear Creek Road (FR 278), as necessary, from Highway 2 to the repository site. Upgrade FR 867 from the repository to the intersection with FR 6213, as necessary. FR 6213, from FR 867 to the Snowshoe Mine Site, would require significant upgrades (including widening and construction of turnouts) to facilitate safe access by construction crews and equipment.

- Install temporary construction bridge cross Snowshoe Creek.

- Implement construction BMPs to protect surface water resources during site reclamation activities.

- Construct the repository at the designated location.

- Provide temporary diversion of Snowshoe Creek and conduct dewatering activities to facilitate excavation of the tailings.

- Excavate, transport, and dispose of tailings material in repository.

- Grade the floodplain area to reduce slopes and provide surfaces amenable to cover soil placement and revegetation.

- Reconstruct Snowshoe Creek streambed, channel and floodplain through the tailings excavation area.

- Recontour and amend the WR-4 with lime.

- Place cover soil at a minimum depth of 12 inches in the tailings excavation area and over WR-4.

- Install diversion ditches to facilitate run-on/runoff controls around the perimeter of the reclaimed sources.

- Revegetate and mulch all disturbed areas upon completion of the construction activities (temporary roads, staging areas, cover soil application areas, etc.).

- Install erosion control mat over WR-4.

- Hard armor eastern perimeter of WR-4 in area of intermittent drainage.

- Install bat-friendly adit closures at two open adits located in the vicinity of the upper waste rock dumps.

- Install 4-strand barbed wire fences surrounding the reclaimed areas.

Access to the site from Libby is adequate to transport crews, equipment, and construction materials. Some portions of the Bear Creek Road (FR 278) and FR 867 may require minor upgrades to accommodate heavy equipment. FR 6213, from the borrow area to the Snowshoe Mine Site would require significant upgrades (approximately 3 miles).

The proposed cover soil source is located approximately 3 miles east of the mine site (Site B-1). Based on analytical results from the repository site investigation, the cover soil contains very little organic matter (1 to 3%), is nutrient-poor, and would require fertilizer application and amendment with organic matter to establish a suitable plant growth medium.

Seeding would likely take place during the fall of the year. The seed mixture and fertilizer would be applied simultaneously to the prepared seedbeds via drill application. Mulch would be applied to promote temporary protection of the disturbed surfaces. Straw mulch (certified weed-free) would be applied over the reclaimed materials with a tow spreader or pneumatic spreader utilizing tucking/crimping as the anchoring mechanism.

Run-on/runoff controls would be achieved by construction of necessary diversion structures. Temporary surface water diversions (e.g., culvert, pipe, lined ditch, etc.) may need to be constructed to control storm water and BMPs would be implemented to prevent runoff and sedimentation into Snowshoe Creek during construction activities.

Effectiveness - The primary purpose of this alternative is to minimize human and terrestrial exposure to the contaminants. This alternative would effectively reduce solid media contaminant mobility and availability at the site by removing the highest risk solid media contaminant sources and disposing of the waste in a secure disposal facility. In addition, any potential surface water erosion problems would be mitigated. Contaminant toxicity and volume would not be reduced; however, the waste would be rendered immobile in an engineered structure and physical location protected from erosion problems. Long-term monitoring and control programs would be necessary to ensure continual effectiveness.

Implementability - This alternative is both technically and administratively feasible. Repository construction, incorporation of amendments, soil covers, and establishing vegetation are readily implementable technologies that use conventional construction techniques. Design methods and requirements have been thoroughly tested and the necessary construction equipment and methods are readily available and widely used. Construction methods may vary depending on the complexity of the terrain and the required depth of amendment incorporation.

Cost Screening - The total capital cost for this alternative has been estimated at $1,842,004 (see Table D-4 in Appendix D), which represents disposal of the highest risk waste source present at the site (tailings) in a constructed repository consisting of a multi-layered cap (design option #2) and in-place containment of WR-4. The total capital cost associated with constructing a repository consisting of a simple soil cover (design option #1) has been estimated at $1,647,279 (see Table D-3 in Appendix D). The total capital cost associated with constructing a repository consisting of a composite bottom liner system and multi-layered cap has been estimated at $2,066,979 (see Table D-5 in Appendix D).

The following assumptions were used to calculate costs for this alternative:

- Recontour WR-4 to a 3:1 configuration (2.9 acres).

- The total volume of tailings material to be excavated and disposed in the repository is 97,000 cubic yards (this volume includes an assumed volume of contaminated natural soil underlying the tailings).

- The excavation for constructing the repository would average approximately 5 feet deep, and the total surface area of the excavation would be approximately 3.5 acres.

- The tailings material would be disposed in the repository at a maximum depth of approximately 16 feet.

- The multi-layered repository cap would consist of a 20 oz. geocushion placed directly over the prepared and compacted wastes; a 30-mil PVC geomembrane liner would be placed over the geocushion; and geocomposite consisting of geonet sandwiched between layers of geotextile filter fabric, would overlay the liner to laterally convey infiltrating precipitation and moisture.

- A two-feet-thick layer of cover soil would overlay the cap drainage layer on the repository.

- An estimated 15,500 cubic yards of cover soil would be hauled from the repository site to cover WR-4, TP-1, and TP-2 to a depth of 12 inches.

- Approximately 2,000 feet of Snowshoe Creek would require stream reconstruction.

- The total surface area at the Snowshoe Mine Site requiring revegetation is approximately 13.6 acres, including the repository.

- Approximately 3,500 lineal feet of run-on/runoff control ditches would be required to protect the reclaimed areas and the repository.

Screening Summary – Removal/disposal of selected waste sources in a constructed repository may be a feasible and cost-effective remedy for the site. Alternative 4a has been retained for detailed analysis.

7.4.7 Alternative 4b: Removal/Disposal of Select Waste Sources in a Constructed Repository and In-Place Containment of Remaining Waste Sources

Alternative 4b involves removal and disposal of selected waste materials in a constructed repository and in-place containment of the remaining waste sources at the Snowshoe Mine Site. Under this alternative, the tailings material and WR-4 would be completely excavated and disposed in the repository (approximately 134,500 cubic yards). The upper waste rock dumps (WR-1, WR-2, and WR-3) would be reclaimed in-place. Additionally, the two open adits in the vicinity of the upper waste rock dumps would be closed using bat-friendly grates. The repository would be constructed at Site B-1 and would consist of a multi-layered cap with no bottom liner system.

Excavation of the tailings would require temporary diversion of Snowshoe Creek and would involve extensive dewatering of the excavation area. Following removal of the tailings, the resulting excavated footprint would be covered with a minimum of 12 inches of cover soil followed by revegetation. Removal of the tailings would also result in complete elimination of the existing streambed, channel and floodplain of Snowshoe Creek; consequently, Snowshoe Creek would need to be reconstructed along its original (pre-mining) alignment. Alternatively, depending on the site conditions following excavation of the tailings, an alpine lake/pond could possibly be constructed in the tailings excavation area.

Complete excavation of WR-4 would require temporary diversion of the small amount of water currently discharging from adit associated with WR-4. After excavation of WR-4 is complete, a small, armored flow channel may need to be established to reduce the potential for erosion in the excavated area.

The upper waste rock dumps (WR-1, WR-2, and WR-3) would be contained in-place by grading, amending with lime (as necessary), covering with a minimum of 12 inches of cover soil, and revegetating. Due to the steepness of these waste rock dumps, the cover soil would also be covered with erosion control mat.

The purpose of establishing vegetation is to stabilize the surface (provide erosion protection) and to decrease net infiltration, through evapotranspiration, into the underlying waste material. Cover soil would be derived from the Site B-1 Repository/Borrow Area as described in Section 3.1.4.3.

Based on the available data and the above considerations, the conceptual design for Alternative 4b includes:

- Upgrade the Bear Creek Road (FR 278), as necessary, from Highway 2 to the repository site. Upgrade FR 867 from the repository to the intersection with FR 6213, as necessary. FR 6213, from FR 867 to the Snowshoe Mine Site, would require significant upgrades (including widening and construction of turnouts) to facilitate safe access by construction crews and equipment.

- Install temporary construction bridge cross Snowshoe Creek.

- Construct access road to the upper waste rock dumps.

- Implement construction BMPs to protect surface water resources during site reclamation activities.

- Construct the repository at the designated location.

- Provide temporary diversion of Snowshoe Creek and conduct dewatering activities to facilitate excavation of the tailings.

- Excavate, transport, and dispose of tailings and WR-4 material in repository.

- Grade the floodplain area and WR-4 excavation area to reduce slopes and provide surfaces amenable to cover soil placement and revegetation.

- Reconstruct Snowshoe Creek streambed, channel and floodplain through the tailings excavation area.

- Place cover soil at a minimum depth of 12 inches in the tailings and WR-4 excavation areas.

- Recontour and amend the upper waste rock dumps with lime, place cover soil to a depth of 12 inches, and revegetate.

- Install erosion control mat over the reclaimed upper waste rock dumps as well as over the lower (northern) portion of WR-4 excavation area.

- Install diversion ditches to facilitate run-on/runoff controls around the perimeter of the reclaimed sources and the repository.

- Revegetate and mulch all disturbed areas upon completion of the construction activities (temporary roads, staging areas, cover soil application areas, etc.).

- Install bat-friendly adit closures at two open adits located in the vicinity of the upper waste rock dumps.

- Obliterate and reclaim the newly constructed access road to the upper waste rock dumps.

- Install 4-strand barbed wire fences surrounding the reclaimed areas.

Access to the site from Libby is adequate to transport crews, equipment, and construction materials. Some portions of the Bear Creek Road (FR 278) and FR 867 may require minor upgrades to accommodate heavy equipment. FR 6213, from the borrow area to the Snowshoe Mine Site would require significant upgrades (approximately 3 miles). Under this alternative, a new road would need to be constructed to allow access to the upper waste rock dumps. Due to the extremely steep topography of the area, the road would include several switchbacks and would need to be approximately 5,000 feet in total length to provide a suitable grade for construction equipment. Construction of this road would be a major endeavor and would require a large investment in both time and capital under this alternative.

The proposed cover soil source is located approximately 3 miles east of the mine site (Site B-1). Based on analytical results from the repository site investigation, the cover soil contains very little organic matter (1 to 3%), is nutrient-poor, and would require fertilizer application and amendment with organic matter to establish a suitable plant growth medium.

Seeding would likely take place during the fall of the year. The seed mixture and fertilizer would be applied simultaneously to the prepared seedbeds via drill application. Mulch would be applied to promote temporary protection of the disturbed surfaces. Straw mulch (certified weed-free) would be applied over the reclaimed materials with a tow spreader or pneumatic spreader utilizing tucking/crimping as the anchoring mechanism.

Run-on/runoff controls would be achieved by construction of necessary diversion structures. Temporary surface water diversions (e.g., culvert, pipe, lined ditch, etc.) may need to be constructed to control storm water and BMPs would be implemented to prevent runoff and sedimentation into Snowshoe Creek during construction activities.

Effectiveness - The primary purpose of this alternative is to minimize human and terrestrial exposure to the contaminants. This alternative would effectively reduce solid media contaminant mobility and availability at the site by removing the highest risk solid media contaminant sources and disposing of the waste in a secure disposal facility. In addition, any potential surface water erosion problems would be mitigated. Contaminant toxicity and volume would not be reduced; however, the waste would be rendered immobile in an engineered structure and physical location protected from erosion problems. Long-term monitoring and control programs would be necessary to ensure continual effectiveness.

Implementability - This alternative is both technically and administratively feasible; however, construction of a road capable of providing safe access for the required equipment to the upper waste rock dumps would be challenging and time consuming. Repository construction, incorporation of amendments, soil covers, and establishing vegetation are readily implementable technologies that use conventional construction techniques. Design methods and requirements have been thoroughly tested and the necessary construction equipment and methods are readily available and widely used. Construction methods may vary depending on the complexity of the terrain and the required depth of amendment incorporation.

Cost Screening - The total capital cost for this alternative has been estimated at $2,346,901 (see Table D-7 in Appendix D), which represents disposal of the highest risk waste sources present at the site (tailings and WR-4) in a constructed repository consisting of a multi-layered cap (design option #2). The total capital cost associated with constructing a repository consisting of a simple soil cover (design option #1) has been estimated at $2,073,895 (see Table D-6 in Appendix D). The total capital cost associated with constructing a repository consisting of a composite bottom liner system and multi-layered cap has been estimated at $2,662,257 (see Table D-8 in Appendix D).

The following assumptions were used to calculate costs for this alternative:

- The access road to the upper waste rock dumps would be approximately 4,900 lineal feet and would include insloping and construction of a safety berm in compliance with MSHA regulations.

- The total volume of tailings material to be excavated and disposed in the repository is 134,500 cubic yards (this volume includes an assumed volume of contaminated natural soil underlying the tailings and WR-4).

- The excavation for constructing the repository would average approximately 5 feet deep, and the total surface area of the excavation would be approximately 4.9 acres.

- The waste materials would be disposed in the repository at a maximum depth of approximately 16 feet.

- The multi-layered repository cap would consist of a 20 oz. geocushion placed directly over the prepared and compacted wastes; a 30-mil PVC geomembrane liner would be placed over the geocushion; and geocomposite consisting of geonet sandwiched between layers of geotextile filter fabric, would overlay the liner to laterally convey infiltrating precipitation and moisture.

- A two-foot thick layer of cover soil would overlay the cap drainage layer on the repository.

- An estimated 16,550 cubic yards of vegetative cover is required to cover the excavated footprint of WR-4, TP-1, and TP-2 and the regraded surfaces of WR-1, WR-2, and WR-3 to a depth of 12 inches. Excavation and subsequent set aside of vegetative cover to reclaim the Site B-1 Borrow Area is estimated at 32,200 cubic yards.

- Approximately 2,000 feet of Snowshoe Creek would require stream reconstruction.

- The total surface area at the Snowshoe Mine Site requiring revegetation is approximately 18.6 acres, including the repository.

- Approximately 3,500 lineal feet of run-on/runoff control ditches would be required to protect the reclaimed areas and the repository.

Screening Summary – Removal/disposal of selected waste sources in a constructed repository and in-place containment of the remaining waste sources may be a feasible and cost-effective remedy for the site. Alternative 4b has been retained for detailed analysis.

7.4.8 Alternative 5: Removal/Disposal of All Waste Sources to an Off-Site Disposal Facility

Alternative 5 involves removal of all waste source materials present at the Snowshoe Mine Site (approximately 138,500 cubic yards) and disposal at an approved off-site disposal facility or a Montana Class 2 Landfill. Additionally, the two open adits in the vicinity of the upper waste rock dumps would be closed using bat-friendly grates. The footprint of the excavated waste sources would be covered with a suitable vegetative cover and seeded with an appropriate seed mix. The purpose of establishing vegetation is to stabilize the surface (provide erosion protection) and to decrease net infiltration, through evapotranspiration, into the underlying waste material. Vegetative cover will be derived from the Site B-1 Repository/Borrow Area as described in Section 3.1.4.3.

Excavation of the tailings would require temporary diversion of Snowshoe Creek and would involve extensive dewatering of the excavation area. Following removal of the tailings, the resulting excavated footprint would be covered with a minimum of 12 inches of cover soil followed by revegetation. Removal of the tailings would also result in complete elimination of the existing streambed, channel and floodplain of Snowshoe Creek; consequently, Snowshoe Creek would need to be reconstructed along its original (pre-mining) alignment. Alternatively, depending on the site conditions following excavation of the tailings, an alpine lake/pond could possibly be constructed in the tailings excavation area.

Complete excavation of WR-4 would require temporary diversion of the small amount of water currently discharging from adit associated with WR-4. After excavation of WR-4 is complete, a small, armored flow channel may need to be established to reduce the potential for erosion in the excavated area. Due to the steepness of the lower (northern) portion of WR-4 and the upper waste rock dumps, the cover soil placed at these excavated areas would also be covered with erosion control mat.

The purpose of establishing vegetation is to stabilize the surface (provide erosion protection) and to decrease net infiltration, through evapotranspiration, into the underlying waste material. Cover soil would be derived from the Site B-1 Repository/Borrow Area as described in Section 3.1.4.3.

Based on the available data and the above considerations, the conceptual design for Alternative 5 includes:

- Upgrade the Bear Creek Road (FR 278), as necessary, from Highway 2 to the borrow area. Upgrade FR 867 from the borrow area to the intersection with FR 6213, as necessary. FR 6213, from FR 867 to the Snowshoe Mine Site, would require significant upgrades (including widening and construction of turnouts) to facilitate safe access by construction crews and equipment.

- Install temporary construction bridge cross Snowshoe Creek.

- Construct access road to the upper waste rock dumps.

- Implement construction BMPs to protect surface water resources during site reclamation activities.

- Develop the borrow area at the designated location.

- Provide temporary diversion of Snowshoe Creek and conduct dewatering activities to facilitate excavation of the tailings.

- Excavate, transport, and dispose of tailings and WR-4 material in repository.

- Grade all excavated area to reduce slopes to the extent possible to provide surfaces amenable to cover soil placement and revegetation.

- Reconstruct Snowshoe Creek streambed, channel and floodplain through the tailings excavation area.

- Place cover soil at a minimum depth of 12-inches in all excavation areas and revegetate.

- Install erosion control mat over the reclaimed upper waste rock dumps as well as over the lower (northern) portion of WR-4 excavation area.

- Install diversion ditches to facilitate run-on/runoff controls around the perimeter of the reclaimed sources and the borrow area.

- Revegetate and mulch all disturbed areas upon completion of the construction activities (temporary roads, staging areas, cover soil application areas, etc.).

- Install bat-friendly adit closures at two open adits located in the vicinity of the upper waste rock dumps.

- Obliterate and reclaim the newly constructed access road to the upper waste rock dumps.

- Install 4-strand barbed wire fences surrounding the reclaimed areas.

Access to the site from Libby is adequate to transport crews, equipment, and construction materials. Some portions of the Bear Creek Road (FR 278) and FR 867 may require minor upgrades to accommodate heavy equipment. FR 6213, from the borrow area to the Snowshoe Mine Site would require significant upgrades (approximately 3 miles). Under this alternative, a new road would need to be constructed to allow access to the upper waste rock dumps. Due to the extremely steep topography of the area, the road would include several switchbacks and would need to be approximately 5,000 feet in total length to provide a suitable grade for construction equipment. Construction of this road would be a major endeavor and would require a large investment in both time and capital under this alternative.

The proposed cover soil source is located approximately 3 miles east of the mine site (Site B-1). Based on analytical results from the repository site investigation, the cover soil contains very little organic matter (1 to 3%), is nutrient-poor, and would require fertilizer application and amendment with organic matter to establish a suitable plant growth medium.

Seeding would likely take place during the fall of the year. The seed mixture and fertilizer would be applied simultaneously to the prepared seedbeds via drill application. Mulch would be applied to promote temporary protection of the disturbed surfaces. Straw mulch (certified weed-free) would be applied over the reclaimed materials with a tow spreader or pneumatic spreader utilizing tucking/crimping as the anchoring mechanism.

Run-on/runoff controls would be achieved by construction of necessary diversion structures. Temporary surface water diversions (e.g., culvert, pipe, lined ditch, etc.) may need to be constructed to control storm water, and BMPs would be implemented to prevent runoff and sedimentation into Snowshoe Creek during construction activities.

Effectiveness – This alternative would effectively reduce contaminant mobility at the site by completely removing contaminant sources; consequently, the site problems are expected to be permanently corrected. Contaminant toxicity and volume would not be reduced, but would be permanently transferred to a different physical location. Disposal at an off-site facility establishes long-term monitoring and control programs to ensure continued effectiveness. However, short-term risks of exposure to the contaminated material would occur during transport to the disposal facility.

Implementability – This alternative is both technically and administratively feasible. The construction steps required (excavation and loadout) are considered standard construction practices. Key project components, such as the availability of equipment, materials, and disposal facilities with adequate capacity, are all present and would help ensure the timely implementation and successful execution of the proposed plan.

Cost Screening - The total capital cost for Alternative 5 has been estimated to be $38,701,824.

The following assumptions were used to calculate costs for this alternative:

- The access road to the upper waste rock dumps would be approximately 4,900 lineal feet and would include insloping and construction of a safety berm in compliance with MSHA regulations.
- The total volume of material to be excavated, transported and disposed is 138,500 cubic yards (this volume includes an assumed volume of contaminated natural soil underlying the waste sources).
- Waste treatment, disposal fees, and taxes would be incurred for the 138,500 cubic yards.
- An estimated 16,500 cubic yards of vegetative cover is required to cover the footprints of TP-1, TP-2 WR-1, WR-2, WR-3, and WR-4 to a depth of 12 inches. Excavation and subsequent set aside of vegetative cover to reclaim the Site B-1 Borrow Area is estimated at 4,360 cubic yards.
- Approximately 2,000 feet of Snowshoe Creek would require stream reconstruction.
- The total surface area at the Snowshoe Mine Site requiring revegetation is approximately 16 acres, including the borrow area.
- Approximately 3,500 lineal feet of run-on/runoff control ditches would be required to protect the reclaimed areas.

Screening Summary – Removal/disposal of selected waste sources may be feasible, but the extreme cost of implementing Alternative 5 eliminates this alternative from further consideration. Alternative 5 has been eliminated from detailed analysis.

7.5 SUMMARY OF ALTERNATIVES SCREENING

Table 7-5 summarizes the results of the preliminary evaluation and screening. Costs generated and summarized on this table are capital costs.

TABLE 7-5
PRELIMINARY EVALUATION AND SCREENING OF ALTERNATIVES

ALTERNATIVE DESCRIPTION	EFFECTIVENESS	IMPLEMENTABLE	ESTIMATED COST	RETAINED FOR DETAILED ANALYSIS
Alternative 1: No Action	NA	NA	$0	Yes
Alternative 2: Institutional Controls	Low	Yes	$108,000	No
Alternative 3a: In-Place Containment of Select Waste Sources	Low	Yes	$652,586	No
Alternative 3b: In-Place Containment of All Waste Sources	Low	Yes	$888,355	No
Alternative 4a: Removal/Disposal of Tailings in a Constructed Repository and In-Place Containment of WR-4	Moderate/High	Yes	$1,647,279 – $2,066,979	Yes
Alternative 4b: Removal/Disposal of Select Waste Sources in a Constructed Repository and In-Place Containment of Remaining Waste Sources	Moderate/High	Yes	$2,073,895 - $2,662,257	Yes
Alternative 5: Removal/Disposal of All Waste Sources in an Off-site Facility	High	Yes	$38,701,824	No

8.0 DETAILED ANALYSIS OF RECLAMATION ALTERNATIVES

The purpose of the detailed analyses is to evaluate in detail, reclamation alternatives for their effectiveness, implementability, and cost to control and reduce the toxicity, mobility, and/or volume of contaminated mine wastes at the Snowshoe Mine Site. Only those reclamation alternatives that were retained after the preliminary evaluation and screening, as presented in Section 7.4, are included. For clarity, the retained alternative numbers are carried over from Section 7.4. Each reclamation alternative currently being considered for implementation at the Snowshoe Mine Site is classified as an interim or removal action and is not considered a complete remedial action. The reclamation alternatives evaluated in detail are applicable to the contaminated solid media; no reclamation alternatives for groundwater, surface water, or contaminated stream sediments are analyzed in detail. The rationale for not directly developing reclamation alternatives for these environmental media is based primarily on the presumption that reclaiming the contaminant source(s) will subsequently reduce or eliminate any problems associated with groundwater, surface water, or stream sediments over time at a significantly reduced cost.

As required by the CERCLA and the NCP, reclamation alternatives that were retained after the initial evaluation and screening have been evaluated individually against the following criteria:

- Overall protection of human health and the environment;
- Compliance with ARARs;
- Long-term effectiveness;
- Reduction of toxicity, mobility, or volume through treatment;
- Short-term effectiveness;
- Implementability; and
- Cost.

The analysis criteria have been used to address the CERCLA requirements and considerations, as outlined in *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA, 1988), as well as additional technical and policy considerations. These criteria serve as the basis for conducting the detailed analysis and subsequently selecting the preferred reclamation alternative. The criteria listed above are categorized into three groups, each with distinct functions in selecting the preferred alternative. These groups include:

- **Threshold Criteria** - Overall protection of human health and the environment and compliance with ARARs;

- **Primary Balancing Criteria** - Long-term effectiveness and permanence; reduction of toxicity, mobility, or volume through treatment; short-term effectiveness; implementability; and cost; and

- **Modifying Criteria** - State and community acceptance.

Overall protection of human health and the environment and compliance with ARARs are threshold criteria that must be satisfied for an alternative to be eligible for selection. Long-term effectiveness and permanence; reduction of toxicity, mobility, or volume; short-term effectiveness; implementability; and cost are the primary balancing factors used to weigh major trade-offs between alternative waste management strategies. Supporting and community acceptance are modifying considerations that are formally considered after public comment is received on the proposed plan (Federal Register, No. 245, 51394-50509, December 1988). Each criterion is briefly described in the following paragraphs.

Overall Protection of Human Health and the Environment - This criterion evaluates how the alternative, as a whole, protects and maintains human health and the environment. The overall assessment of protection is based on a combination of factors assessed under other evaluation criteria, especially long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs.

Compliance with ARARs - This criterion assesses how each alternative complies with applicable or relevant and appropriate standards, criteria, advisories, or other guidelines. Waivers will be identified, if necessary. The following factors will be addressed for each alternative during the detailed analysis of ARARs:

- Compliance with chemical-specific ARARs;
- Compliance with action-specific ARARs;
- Compliance with location-specific ARARs; and
- Compliance with appropriate criteria, advisories, and guidelines.

Long-term Effectiveness and Permanence - This criterion evaluates the alternative's effectiveness in protecting human health and the environment after response objectives have been met. The following components of the criterion will be addressed for each alternative:

- Magnitude of residual risk;
- Adequacy of controls; and
- Reliability of controls.

Reduction of Toxicity, Mobility, or Volume Through Treatment – This criterion evaluates anticipated performance of the specific treatment technologies. This evaluation focuses on the following specific factors for a particular reclamation alternative:

- The treatment process, the remedies they will employ, and the materials they will treat;
- The amount of hazardous materials that will be destroyed or treated, including how principal threat(s) will be addressed;
- The degree of expected reduction in toxicity, mobility, or volume measured as a percentage of reduction (or order of magnitude);
- The degree to which the treatment will be irreversible; and
- The type and quantity of treatment residuals (e.g., wastewater treatment sludges, spent reagents) that will remain following treatment.

Short-term Effectiveness – This criterion evaluates an alternative's effectiveness in protecting human health and the environment during the construction and implementation period until the response objectives are met. Factors that will be considered under this criterion include:

- Protection of the surrounding community during reclamation actions;
- Protection of on-site workers during reclamation actions;
- Protection from environmental impacts; and
- Time until removal response objectives are achieved.

Implementability – This criterion evaluates the technical and administrative feasibility of alternatives and the availability of required resources. Analysis of this criterion will include the following factors and subfactors:

Technical Feasibility

- Construction and operation;
- Reliability of the technology;
- Ease of undertaking additional reclamation actions (if necessary); and
- Monitoring considerations.

Administrative Feasibility

- Resource Conservation and Recovery Act (RCRA) disposal restrictions;
- Institutional controls; and
- Permitting requirements.

The cost assessment evaluates the estimated capital cost associated with each alternative. Cost screening consists of developing conservative, order-of-magnitude cost estimates based on similar sets of site-specific assumptions. Cost estimates for each alternative will consider the following factors:

Capital Cost

- Construction costs;
- Equipment costs;
- Land and site development costs;
- Disposal costs;
- Legal fees, license, and permit costs;
- Start up and troubleshooting costs; and
- Contingency allowances.

Annual Costs

- Operating labor;
- Disposal residues;
- Administrative costs;

- Insurance, taxes, and licensing;
- Contingency funds, and
- Rehabilitations costs.

Cooperating Agency acceptance will evaluate the technical and administrative issues and concerns the State may have regarding each of the alternatives. State acceptance will also focus on legal issues and compliance with State statutes and regulations. **Community acceptance** will incorporate public concerns into the analyses of the alternatives.

The final step of this analysis is to conduct a comparative analysis of the alternatives. The analysis will include a discussion of the alternative's relative strengths and weaknesses with respect to each of the criteria and how reasonable key uncertainties could change expectations of their relative performance.

Once completed, this evaluation will be used to select the preferred alternative(s). The selection of the preferred alternative(s) will be documented in a Record of Decision by the DEQ/MWCB. A public meeting to present the alternatives will be conducted and relevant oral and written comments will be addressed in writing.

8.1 QUANTITATIVE EVALUATION OF THRESHOLD CRITERIA

In the following detailed evaluations of the threshold criteria, each reclamation alternative contains quantitative estimates of risk reduction as well as estimates regarding whether ARARs would be attained by implementing the alternative. To quantitatively assess the threshold criteria (overall protection of human health and the environment and attainment of ARARs), the exposure pathways of concern that were identified in the baseline risk assessment (human health and ecologic) were evaluated to determine the risk reduction required to achieve the desired residual risk level (HQ = 1.0 and EQ = 1.0). Each alternative was then modeled to ascertain the degree of risk reduction achieved, either through reduced contaminant loadings to an exposure pathway or reduced surface area available for certain exposures. The resulting risk reduction estimates are then compared to one another to determine whether the relative risk reduction provided by a specific alternative is greater than another; these risk reductions are also compared to the reduction required to alleviate excess risk via the specific pathway or media, as determined in the risk assessments. The risk reduction models also estimate resultant contaminant concentrations in the various media, which are then compared to media- and contaminant-specific ARARs. The groundwater model uses an on-site, downgradient exposure point, while the surface water/sediment model uses the sample station location below the sources at the site on Snowshoe Creek as the evaluation point.

Modeling estimates and assumptions are used in an attempt to quantify risk reduction and determine whether ARARs would be attained. In the course of performing this quantitative analysis, several assumptions and estimates are necessarily employed. Some of the assumptions are based on standard CERCLA risk assessment guidance, while others are based on site-specific observations and professional judgment. Many of the estimates are based on conservative (worst case) scenarios, but since alternatives are compared to one another on a relative basis, these assumptions are consistent. The evaluation findings should, therefore, not be considered absolute (e.g., ARARs); however, the relative risk reduction differences between alternatives are meaningful and can be used to evaluate these criteria.

The human health baseline risk assessments determined that the pathways and COCs at the Snowshoe Mine Site were soil ingestion of antimony, arsenic, cadmium, and lead, and water ingestion of arsenic, cadmium, and lead. To effect risk reduction for these contaminants via the corresponding pathways, two scenarios were evaluated in the risk assessment: a recreational exposure and residential exposure. Each reclamation alternative is modeled for the two scenarios and the resultant risk reductions are compared to the reduction required to achieve these levels of protectiveness (recreational and residential): lead via soil ingestion 99% (residential), 97% (recreational); non-carcinogenic arsenic via soil ingestion 99% (residential), 88% (recreational); cadmium via soil ingestion 93% (residential); antimony via soil ingestion 81% (residential); lead via water ingestion 99% (residential); arsenic via water ingestion 92% (residential); cadmium via water ingestion 25% (residential). Refer to Table 6-4 for pathway- and contaminant-specific risk reduction goals.

The ecologic risk assessment identified three exposure scenarios: Snowshoe Creek aquatic life receptors exposed to arsenic, cadmium, copper, lead and zinc in sediments and cadmium, lead, and zinc in water; and plant phytotoxicity to arsenic, cadmium, copper, lead and zinc. The aquatic life-water scenario requires a surface water loading reduction of 90% to achieve ambient water quality criteria standards (acute cadmium). The aquatic life-sediment scenario requires a 99% reduction in additional sediment loading to the creek to achieve preliminary sediment quality criteria - median effect range (lead). The plant phytotoxicity scenario requires a 99% reduction in surface concentrations or area to achieve no phytotoxic effects from lead.

The three exposure pathways were modeled to evaluate the relative risk reductions and attainment of ARARs afforded by each alternative. These calculations involved a combination of measured data collected at the site (waste and surface water concentrations), and modeled impacts (e.g., groundwater loading). A discussion of how the evaluations were performed and the assumptions used follows for each pathway.

The groundwater pathway was modeled using a simple mathematical model that utilized two components: estimates of leachate concentrations for precipitation water that flows through the waste sources and/or repository and ultimately into groundwater; and estimates of the rate that this water flows through the wastes and/or repository (flux). The first component, leachate concentrations, was obtained by using the TCLP analyses performed during the 2002 RI on composite samples of the waste sources. The second component, water flux through the sources, was estimated using the Hydrologic Evaluation of Landfill Performance model (Visual HELP, Version 2.2) that uses a variety of site meteorological and physical data to determine the water balance at the site, including estimating the volume of water flux through the bottom of a constructed impoundment. Each source was evaluated, as was the background groundwater. Assumptions used to evaluate groundwater impacts (loadings) include the following: inputs from the sources and background were summed, which has the effect of assuming complete mixing and not considering any other contaminant attenuation mechanisms. Repository groundwater loads were evaluated separately as they are remote from the mine site and represent a separate groundwater loading.

The surface water pathway was also modeled using a simple mathematical model. This model utilized two components: measured surface water concentrations above and below the site wastes; and an estimate of the relative increases in surface water loading provided by each source. These estimates are based on relative contaminant concentrations in each source, the area of the source, and proximity of each source to a surface water conveyance.

Assumptions used to evaluate surface water impacts (loadings) include the following: alternatives that employed simple soil covers or caps were assigned a 65% long-term effectiveness for preventing erosion into surface water, soil caps on a repository were assigned a 75% long-term effectiveness for preventing erosion into surface water; sources placed in an off-site repository with a multi-layered (impermeable) cap were assumed to have been 90% removed from exposures via this pathway; and sources moved to an off-site TSD facility were assumed to have been 100% removed from exposures via this pathway. Surface water modeling considered an exposure point concentration in Snowshoe Creek downstream from the wastes at the Snowshoe Mine Site.

The soil exposure pathways were empirically modeled using only reductions in surface area to estimate reduction in exposures. This pathway also assumed that alternatives employing simple soil covers or caps were assigned a 65% long-term effectiveness for preventing erosion into surface water, soil caps on a repository were assigned a 75% long-term effectiveness for preventing erosion into surface water; sources placed in an off-site repository with a multi-layered (impermeable) cap were assumed to have been 90% removed from exposures via this pathway; and sources moved to an off-site TSD facility were assumed to have been 100% removed from exposures via this pathway.

8.2 ALTERNATIVE 1: NO ACTION

The No Action Alternative is required for analysis by CERCLA and the NCP when evaluating alternatives. The No Action Alternative is used to provide a baseline for comparing other alternatives. Under this alternative, no permanent reclamation activities would be implemented. Consequently, long-term human health and environmental risks associated with the on-site contamination would remain unchanged, with the contaminant sources at the site continuing to pose a threat to human health and environmental resources.

8.2.1 Overall Protection of Human Health and the Environment

The No Action Alternative provides no control of exposures to contaminated materials and no reduction in risk to human health or the environment. It allows for the continued migration of contaminants and further degradation of groundwater, sediment and surface water quality.

Protection of human health would not be achieved under the No Action Alternative. Prevention of human exposure to COCs via the pathways of concern, as identified in the human health risk assessment, would not occur. Soil ingestion exposure to antimony, arsenic, cadmium, and lead Sb via contaminated surface soil and groundwater ingestion of arsenic, cadmium and lead would not be reduced, meeting none of the risk reduction goals.

Protection of the environment would also not be achieved under the No Action Alternative. Prevention of ecologic exposures via all the scenarios identified in the ecologic risk assessment would not occur: aquatic life exposure to cadmium, lead and zinc via water and arsenic, cadmium, copper, lead, and zinc via sediment; and plant phytotoxicity to arsenic, cadmium, copper, lead, and zinc.

A risk reduction achievement matrix (Table 8-1) was developed to assess whether the alternative affords sufficient protection to human health and the environment for the pathways and COCs identified in the human health risk assessment and the ecological risk assessment. The conclusions presented in the table are based on worst-case modeling results subject to the limitations and assumptions used in the models.

TABLE 8-1
RISK REDUCTION ACHIEVEMENT MATRIX - ALTERNATIVE 1

Alternative 1	As	Cd	Pb	Cu	Zn	Overall
Human Health Exposure Pathways:						
Soil Ingestion	None	None	None	Res.	Res.	None
Water Ingestion	Recr.	Recr.	Recr.	Res.	Res.	Recr.
Ecologic Exposure Pathways:						
Surface Water	--	No	No	–	No	No
Sediments	No	No	No	No	No	No
Plant Phytotoxicity	No	No	No	No	No	No

-- = Risk reduction not required for the contaminant for that pathway.
None = Does not achieve required risk reduction for any exposure scenario.
Recr. = Achieves required risk reduction for the recreational exposure scenario.
Res. = Achieves required risk reduction for the residential exposure scenario (most protective).

8.2.2 Compliance with ARARs

A comprehensive list of Federal and State ARARs has been developed for the Snowshoe Mine Site and is summarized in Section 4.0 and presented in detail in Appendix C. The ARARs are divided into contaminant-specific, location-specific, and action-specific requirements. Contaminant-specific ARARs are waste-related requirements which specify how a waste must be managed, treated, and/or disposed depending upon the classification of the waste material. Location-specific ARARs specify how the remedial activities must take place depending upon where the wastes are physically located (e.g., in a stream or floodplain, wilderness area, or sensitive environment, etc.), or where the wastes may be treated or disposed, and what authorizations (permits) may be required. Action-specific ARARs are technology- or activity-based requirements, or are limitations on actions taken with respect to hazardous substances. Action-specific ARARs do not determine the preferred reclamation alternative, but indicate how the selected alternative must be achieved.

Under the No Action Alternative, no contaminated materials would be treated, removed, or actively managed. Consequently, the No Action Alternative would not satisfy Federal or State ARARs. A water quality ARARs attainment matrix (Table 8-2) was developed to assess whether the alternative can achieve ARARs for those contaminants and media where they are exceeded. The conclusions presented in the table are based on worst-case modeling results subject to the limitations and assumptions used in the models (see Section 8.1 for discussion).

TABLE 8-2
WATER QUALITY ARARs ATTAINMENT FOR ALTERNATIVE 1

Alternative 1	As	Cd	Cu	Pb	Zn
On-site Groundwater (µg/L)	1.1	14	NM	620	NM
On-site Surface water (µg/L)	2.7	6.0	3.3	21	350
On-site Groundwater ARARs	Yes	No	--	No	--
On-site Surface Water ARARs	Yes	No	Yes	No	No

Groundwater ARARs are State HHSs.
Surface water ARARs are State HHSs or Acute AWQC, whichever is lower.
NM = Contaminant not modeled (Cu and Zn not included in TCLP suite).
µg/L = micrograms per Liter

On-site groundwater would exceed water quality ARARs for cadmium and lead (HHS). On-site surface water would exceed water quality ARARs for cadmium and lead (HHS and Acute Ambient Water Quality Criteria [AWQC]), and zinc (Acute AWQC).

8.2.3 Long-Term Effectiveness and Permanence

No controls or long-term measures would be placed on the contaminated materials at the sites; consequently, all current and future risks would remain the same as described in the baseline risk assessment. Therefore, the No Action Alternative would not be effective at minimizing risks from exposure to these materials. The time required until reclamation objectives are reached (by natural contaminant degradation and erosion) would be indefinite and would most likely be measured in terms of geologic time frames.

8.2.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

The No Action Alternative would provide no reduction in toxicity, mobility, or volume of the contaminated materials.

8.2.5 Short-Term Effectiveness

In the short term, the No Action Alternative would pose no additional threats to the community or the environment because the current site conditions would not be changed. The identical level of risk as identified in the risk assessment (Section 5.0) would continue to exist in the short and long term.

8.2.6 Implementability

There would be no implementability concerns posed by the No Action Alternative since no action would be taken.

8.2.7 Costs

The cost for implementing this alternative would be zero since no action would be taken.

8.3 ALTERNATIVE 4a: REMOVAL/DISPOSAL OF TAILINGS IN A CONSTRUCTED REPOSITORY AND IN-PLACE CONTAINMENT OF WR-4

Section 7.4.6 of this document presents the conceptual design, design assumptions, logistics, and construction details associated with Alternative 4a.

8.3.1 Overall Protection of Human Health and the Environment

Significant protection of human health would be achieved under this alternative. Reduction of human exposures to the COCs via the pathways of concern, as identified in the human health risk assessment, would occur. However, soil ingestion exposure to arsenic and lead via contaminated surface soil would not be sufficiently reduced for recreational exposures. Arsenic, cadmium and lead would also not be reduced enough to meet the residential risk reduction goals. Groundwater ingestion of arsenic and lead would also not be reduced enough to meet residential risk reduction goals.

Significant protection of the environment would be achieved under this alternative. Reduction of most ecologic exposures, via the scenarios identified in the ecologic risk assessment, would occur: aquatic life exposure to cadmium and zinc in water, and to arsenic, cadmium, lead, and zinc via sediment would be sufficiently reduced; however, plant phytotoxicity to arsenic, cadmium, copper, lead and zinc would not be sufficiently reduced.

A risk reduction achievement matrix (Table 8-3) was developed to assess whether the alternative affords sufficient protection of human health and the environment for the pathways and COCs identified in the human health risk assessment (Section 5.1) and the ecological risk assessment (Section 5.2). The conclusions presented in the table are based on worst-case modeling results subject to the limitations and assumptions used in the models (see Section 8.1 for discussion).

TABLE 8-3
RISK REDUCTION ACHIEVEMENT MATRIX - ALTERNATIVE 4a

Alternative 4a	As	Cd	Pb	Cu	Zn	Overall
Human Health Exposure Pathways:						
Soil Ingestion	None	Recr.	None	Res.	Res.	None
Water Ingestion	Recr.	Res.	Recr.	Res.	Res.	Recr.
Ecologic Exposure Pathways:						
Surface Water	--	Yes	Yes	–	Yes	Yes
Sediments	Yes	Yes	Yes	Yes	Yes	Yes
Plant Phytotoxicity	No	No	No	No	No	No

-- = Risk reduction not required for the contaminant for that pathway.
None = Does not achieve required risk reduction for any exposure scenario.
Recr. = Achieves required risk reduction for the recreational exposure scenario.
Res. = Achieves required risk reduction for the residential exposure scenario (most protective).

8.3.2 Compliance with ARARs

All location-specific and action-specific ARARs would be met by implementing this alternative. There are no chemical-specific ARARs that apply to containment of contaminated solid media in a repository.

Not all water quality ARARs are expected to be achieved by implementing this alternative. A water quality ARAR attainment matrix (Table 8-4) was developed to assess whether the alternative can achieve ARARs for those contaminants and media where they are currently exceeded. The conclusions presented in the table are based on worst-case modeling results subject to the limitations and assumptions used in the models (see Section 8.1 for discussion).

TABLE 8-4
WATER QUALITY ARARs ATTAINMENT FOR ALTERNATIVE 4a

ALTERNATIVE 4a	As	Cd	Cu	Pb	Zn
On-site Groundwater (μg/L)	0.7	6.5	NM	260	NM
Repository Area Groundwater (μg/L):					
Design 1 – Soil Cap, No Liner	1.0	4.5	NM	305	NM
Design 2 – Multi-layered Cap	0.5	0.04	NM	0.7	NM
Design 3 – Bottom Liner and Multi-layered Cap	0.5	0.04	NM	0.4	NM
On-site Surface water (μg/L)	1.2	0.2	2.6	1.1	15
On-site Groundwater ARARs	Yes	No	--	No	--
Repository Groundwater ARARs:					
Design Option 1	Yes	Yes	--	No	--
Design Options 2 and 3	Yes	Yes	--	Yes	--
Onsite Surface Water ARARs	Yes	Yes	Yes	Yes	Yes

Groundwater ARARs are State HHSs.
Surface water ARARs are State HHSs or Acute AWQC, whichever is lower.
NM = Contaminant not modeled (Cu and Zn not included in TCLP suite).
μg/L = micrograms per Liter

By implementing this alternative, on-site groundwater is expected to exceed water quality ARARs for cadmium and lead (HHS). Repository area groundwater would exceed water quality ARARs for lead (HHS) for Design Option 1; however, repository area groundwater quality ARARs would be met by implementing Design Options 2 and 3. On-site surface water is expected to meet water quality ARARs.

8.3.3 Long-Term Effectiveness and Permanence

Under this alternative, the repository and soil cover placed over WR-4 would have to be maintained to ensure that they continue to perform as designed; consequently, long-term monitoring and frequent inspection and maintenance would be required. The repository cap and soil cover placed over WR-4 would be susceptible to settlement, ponding of surface water, erosion, and disruption of cover integrity by vehicles, deep-rooting vegetation, and burrowing animals. However, the covers could be easily inspected and the required maintenance could be easily determined.

Run-on controls and proper grading are important components of Alternative 4a. These engineered controls would promote runoff from the contained waste areas and would reduce infiltration through the wastes by directing upgradient flows around the reclaimed areas. These run-on controls would have to be maintained to ensure that they continue to perform as designed, and consequently, long-term monitoring and frequent inspection and maintenance would be required.

Capping, cover soil and revegetation would reduce the threat of direct contact and inhalation of airborne contaminants by on-site and nearby receptors. The long-term effectiveness of the covers would be enhanced by carefully determining proper amendments, and selecting appropriate plant species, adapted to short growing seasons and high altitudes.

Over the long term, the water quality and sediment environment (benthic community) in Snowshoe Creek would improve significantly by implementing this alternative. Also, the downstream fishery is expected to benefit because the contaminant sources impacting the stream would be removed from their current, unstable locations.

8.3.4 Reduction of Toxicity, Mobility, of Volume Through Treatment

The primary objective of this alternative is to provide a major reduction in contaminant mobility; waste volume or toxicity would not be reduced by this alternative. The primary waste sources of concern would be rendered essentially immobile in an engineered structure and physical location that is protected from erosion problems. The engineered repository would eliminate the direct contact and surface water exposure pathways, and would reduce leaching of contaminants to groundwater.

Removing the wastes located immediately adjacent to the creek and consolidating these wastes away from the creek would significantly reduce contaminant mobility and resulting surface water impacts. Based on modeling results, this alternative is expected to reduce the mobility of the on-site contaminants to an extent that would result in an overall human health risk reduction (all pathways and all routes of exposure considered) of 61% and an overall ecological risk reduction of 81% for Design Option 1. Design Options 2 and 3 would result in identical overall risk reductions of 64% (human health) and 83% (ecological).

8.3.5 Short-Term Effectiveness

It is anticipated that the construction phase of this alternative would be accomplished in a relatively short time period (one field season); therefore, impacts associated with construction would be short term and minimal. On-site workers would be adequately protected during the construction phase by utilizing appropriate personal protective equipment and by following proper operating and safety procedures; however, short-term water quality and air quality impacts to the surrounding environment may occur due to the large volumes of wastes requiring handling. Control of fugitive dust emissions would be provided by applying water (via water truck) to surfaces receiving heavy vehicular traffic, or in excavation areas, etc.

Short-term impacts to the surrounding community would be minor considering the remoteness of the site. Short-term impacts to the surrounding community would involve increased local vehicle traffic on public roadways and associated safety hazards, as well as increased noise levels and dust generation. Application of water to haul roads will be necessary to mitigate dust generation.

This alternative may impart short-term impacts on Snowshoe Creek due to the need to work in close proximity to the stream and excavate wastes from the floodplain. Additionally, this alternative would require installation of a surface water diversion structure(s) in Snowshoe Creek and allow reconstruction of the stream channel through the current footprint of the tailings.

Short-term impacts to environmental resources are difficult to quantify; however, every effort would be made to minimize impacts to Snowshoe Creek and potential downstream receptors during implementation of this alternative. Excavation of the tailings may expose un-weathered (reduced) tailings materials to water and oxygen that could potentially result in an increased production of acid rock drainage (ARD) over the short term. To minimize this possibility, the newly exposed tailings would be isolated from excess water to the extent practical via dewatering during the excavation process. Dewatering would likely consist of construction of a series of trenches and sumps, and installation of pumps to remove excess water from the immediate excavation area. The exact dewatering method to be employed would be determined during the detailed design phase of the project. Application for water quality permits, required as part of State and Federal Agency approval of the reclamation plan, would also aid in planning for protecting Snowshoe Creek from short-term impacts during the construction phase of the project. Additionally, BMPs would be required to be implemented during construction to protect surface water resources.

8.3.6 Implementability

This alternative is both technically and administratively feasible, and could be implemented in a relatively short period of time (one construction season, assuming favorable weather conditions). The excavation, hauling, lining, compacting, grading, capping, and revegetation steps required are considered conventional construction practices; materials and construction methods are readily available. Also, design methods and requirements are well documented and well understood. However, the construction steps required to implement this alternative are considered moderately difficult due to the need to work with wet tailings.

Factors that could affect the implementability of this alternative include the potential to encounter significant groundwater beneath the tailings when excavating and attempting to operate heavy equipment on wet tailings. If significant groundwater is encountered when excavating the materials, dewatering (e.g., pumping) will likely be required during construction. Additionally, pre-treatment of wet materials may be necessary to eliminate free liquids to attain compaction specifications in the repository. Dewatering and/or pre-treatment, if required, could significantly increase project costs.

8.3.7 Cost

The total capital cost associated with constructing a repository consisting of a simple soil cover (Design Option #1) has been estimated at $1,647,279 (see Table D-3 in Appendix D). The total capital cost associated with constructing a repository consisting of a multi-layered (impermeable) cap has been estimated at $1,842,004 (see Table D-4 in Appendix D). The total capital cost associated with constructing a repository consisting of a composite bottom liner system and multi-layered cap has been estimated at $2,066,979 (see Table D-5 in Appendix D).

8.4 ALTERNATIVE 4b: REMOVAL/DISPOSAL OF SELECT WASTE SOURCES IN A CONSTRUCTED REPOSITORY AND IN-PLACE CONTAINMENT OF REMAINING WASTE SOURCES.

Section 7.4.7 of this document presents the conceptual design, design assumptions, logistics, and construction details associated with Alternative 4b.

8.4.1 Overall Protection of Human Health and the Environment

Significant protection of human health would be achieved under this alternative. Reduction of human exposures to COCs via the pathways of concern, as identified in the human health risk assessment, would occur. However, soil ingestion exposure to arsenic and lead via contaminated surface soil would not be sufficiently reduced for recreational exposures. Arsenic, cadmium and lead would also not be reduced enough to meet the residential risk reduction goals. Groundwater ingestion of arsenic and lead would also not be reduced enough to meet residential risk reduction goals.

Significant protection of the environment would be achieved under this alternative. Reduction of most ecologic exposures via the scenarios identified in the ecologic risk assessment would occur: aquatic life exposure to cadmium and zinc in water, and to arsenic, cadmium, lead and zinc via sediment would be sufficiently reduced; however, plant phytotoxicity to arsenic, cadmium, lead and zinc would not be sufficiently reduced.

A risk reduction achievement matrix (Table 8-5) was developed to assess whether the alternative affords sufficient protection of human health and the environment for the pathways and COCs identified in the human health risk assessment (Section 5.1) and the ecological risk assessment (Section 5.2). The conclusions presented in the table are based on worst-case modeling results subject to the limitations and assumptions used in the models.

TABLE 8-5
RISK REDUCTION ACHIEVEMENT MATRIX - ALTERNATIVE 4b

Alternative 4b	As	Cd	Pb	Cu	Zn	Overall
Human Health Exposure Pathways:						
Soil Ingestion	None	Recr.	None	Res.	Res.	None
Water Ingestion	Recr.	Res.	Recr.	Res.	Res.	Recr.
Ecologic Exposure Pathways:						
Surface Water	--	Yes	Yes	–	Yes	Yes
Sediments	Yes	Yes	Yes	Yes	Yes	Yes
Plant Phytotoxicity	No	No	No	Yes	No	No

-- = Risk reduction not required for the contaminant for that pathway.
None = Does not achieve required risk reduction for any exposure scenario.
Recr. = Achieves required risk reduction for the recreational exposure scenario.
Res. = Achieves required risk reduction for the residential exposure scenario (most protective).

8.4.2 Compliance with ARARs

All location-specific and action-specific ARARs would be met by implementing this alternative. There are no chemical-specific ARARs that apply to containment of contaminated solid media in a repository.

Not all water quality ARARs are expected to be achieved by implementing this alternative. A water quality ARAR attainment matrix (Table 8-6) was developed to assess whether the alternative can achieve ARARs for those contaminants and media where they are currently exceeded. The conclusions presented in the table are based on worst-case modeling results subject to the limitations and assumptions used in the models (see Section 8.1 for discussion).

TABLE 8-6
WATER QUALITY ARARs ATTAINMENT FOR ALTERNATIVE 4b

ALTERNATIVE 4b	As	Cd	Cu	Pb	Zn
On-site Groundwater (µg/L)	0.5	2.2	NM	96	NM
Repository Groundwater (µg/L):					
Design Option 1 – Soil Cap, No Liner	1.6	21	NM	948	NM
Design Option 2 – Multi-Layered Cap	0.5	0.04	NM	0.9	NM
Design Option 3 – Bottom Liner and Multi-Layered Cap	0.5	0.04	NM	0.4	NM
On-site Surface water (µg/L)	1.2	0.1	2.6	1.0	13
On-site Groundwater ARARs	Yes	No	--	No	--
Repository Groundwater ARARs:					
Design Option 1	Yes	No	--	No	--
Design Options 2 and 3	Yes	Yes	--	Yes	--
On-site Surface Water ARARs	Yes	Yes	Yes	Yes	Yes

Groundwater ARARs are State HHSs.
Surface water ARARs are State HHSs or Acute AWQC, whichever is lower.
NM = Contaminant not modeled (Cu and Zn not included in TCLP suite).
µg/L = micrograms per Liter

By implementing this alternative, onsite groundwater would exceed water quality ARARs for cadmium and lead (HHS). Repository area groundwater would exceed water quality ARARs for cadmium and lead (HHS) for Design Option 1; however, repository groundwater quality ARARs would be met by implementing Design Options 2 or 3. On-site surface water is expected to meet water quality ARARs.

8.4.3 Long-Term Effectiveness and Permanence

Under this alternative, the repository and soil covers placed over the upper waste rock dumps would have to be maintained to ensure that they continue to perform as designed; consequently, long-term monitoring and frequent inspection and maintenance would be required. The repository cap and soil covers would be susceptible to settlement, ponding of surface water, erosion, and disruption of cover integrity by vehicles, deep-rooting vegetation, and burrowing animals. However, the covers could be easily inspected and the required maintenance could be easily determined. Due to the excessive steepness of the upper waste rock dumps, erosion of the soil covers in these areas would continue to be a concern. Additionally, any required maintenance of the soil covers on the upper waste rock dumps would be difficult to implement unless the haul road constructed to access this area was allowed to remain intact.

Run-on controls and proper grading are important components of Alternative 4b. These Engineered Controls would promote runoff from the contained waste areas and would reduce infiltration through the wastes by directing upgradient flows around the reclaimed areas. These run-on controls would have to be maintained to ensure that they continue to perform as designed, and consequently, long-term monitoring and frequent inspection and maintenance would be required.

Capping, cover soil and revegetation would reduce the threat of direct contact and inhalation of airborne contaminants by on-site and nearby receptors. The long-term effectiveness of the covers would be enhanced by carefully determining proper amendments, and selecting appropriate plant species, adapted to short growing seasons and high altitudes.

Over the long term, the water quality and sediment environment (benthic community) in Snowshoe Creek would improve significantly by implementing this alternative. Also, the downstream fishery is expected to benefit because the contaminant sources impacting the stream would be removed from their current, unstable locations.

8.4.4 Reduction of Toxicity, Mobility, of Volume Through Treatment

The primary objective of this alternative is to provide a major reduction in contaminant mobility; waste volume or toxicity would not be reduced by this alternative. The primary waste sources of concern would be rendered essentially immobile in an engineered structure and physical location that is protected from erosion problems. The engineered repository would eliminate the direct contact and surface water exposure pathways, and would reduce leaching of contaminants to groundwater.

Removing the wastes located immediately adjacent to the creek and consolidating these wastes away from the creek would significantly reduce contaminant mobility and resulting surface water impacts. Based on modeling results, this alternative is expected to reduce the mobility of the on-site contaminants to an extent that would result in an overall human health risk reduction (all pathways and all routes of exposure considered) of 82% and an overall ecological risk reduction of 91% for Design Option 1. Design Options 2 and 3 would result in identical overall risk reductions of 86% (human health) and 94% (ecological).

8.4.5 Short-Term Effectiveness

It is anticipated that the construction phase of this alternative would be accomplished in a relatively short time period (one field season); therefore, impacts associated with construction would be short term and minimal. On-site workers would be adequately protected during the construction phase by utilizing appropriate personal protective equipment and by following proper operating and safety procedures; however, short-term water quality and air quality impacts to the surrounding environment may occur due to the large volumes of wastes requiring handling. Control of fugitive dust emissions would be provided by applying water (via water truck) to surfaces receiving heavy vehicular traffic, or in excavation areas, etc.

Short-term impacts to the surrounding community would be minor considering the remoteness of the site. Short-term impacts to the surrounding community would involve increased local vehicle traffic on public roadways and associated safety hazards, as well as increased noise levels and dust generation. Application of water to haul roads will be necessary to mitigate dust generation.

This alternative may impart short-term impacts on Snowshoe Creek due to the need to work in close proximity to the stream and excavate wastes from the floodplain. Additionally, this alternative would require installation of a surface water diversion structure(s) in Snowshoe Creek and to allow reconstruction of the stream channel through the current footprint of the tailings.

Short-term impacts to environmental resources are difficult to quantify; however, every effort would be made to minimize impacts to Snowshoe Creek and potential downstream receptors during implementation of this alternative. Excavation of the tailings may expose un-weathered (reduced) tailings materials to water and oxygen that could potentially result in an increased production of ARD over the short term. To minimize this possibility, the newly exposed tailings would be isolated from excess water to the extent practical via dewatering during the excavation process. Dewatering would likely consist of construction of a series of trenches and sumps, and installation of pumps to remove excess water from the immediate excavation area. The exact dewatering method to be employed would be determined during the detailed design phase of the project. Application for water quality permits, required as part of State and Federal Agency approval of the reclamation plan, would also aid in planning for protecting Snowshoe Creek from short-term impacts during the construction phase of the project. Additionally, BMPs would be required to be implemented during construction to protect surface water resources.

8.4.6 Implementability

This alternative is both technically and administratively feasible, and could be implemented in a relatively short period of time (one construction season, assuming favorable weather conditions). The excavation, hauling, lining, compacting, grading, capping, and revegetation steps required are considered conventional construction practices; materials and construction methods are readily available. Also, design methods and requirements are well documented and well understood. However, the construction steps required to implement this alternative are considered moderately difficult due to the need to work with wet tailings.

Factors that could affect the implementability of this alternative include the potential to encounter significant groundwater beneath the tailings when excavating and attempting to operate heavy equipment on wet tailings. If significant groundwater is encountered when excavating the materials, dewatering (e.g., pumping) will likely be required during construction. Additionally, pre-treatment of wet materials may be necessary to eliminate free liquids to attain compaction specifications in the repository. Dewatering and/or pre-treatment, if required, could significantly increase project costs.

Under this alternative, a new road would need to be constructed to allow access to the upper waste rock dumps. Due to the extremely steep topography of the area, the road would include several switchbacks and would need to be approximately 5,000 feet in total length to provide a suitable grade for construction equipment. The access road would also include insloping and construction of a continuous safety berm in compliance with MSHA regulations. Although it is certainly feasible to construct a safe and functional road, it would be a major endeavor and would require a large investment in both time and capital under this alternative.

8.4.7 Cost

The total capital cost associated with constructing a repository consisting of a simple soil cover (Design Option #1) has been estimated at $2,073,895 (see Table D-6 in Appendix D). The total capital cost associated with constructing a repository consisting of a multi-layered (impermeable) cap has been estimated at $2,346,901 (see Table D-7 in Appendix D). The total capital cost associated with constructing a repository consisting of a composite bottom liner system and multi-layered cap has been estimated at $2,662,257 (see Table D-8 in Appendix D).

9.0 COMPARATIVE ANALYSIS OF ALTERNATIVES

This section provides a comparison of the reclamation alternatives that were retained for detailed analysis for the Snowshoe Mine Site. The comparison focuses mainly on the following criteria: 1) relative protectiveness of human health and the environment that would be provided by the alternatives; 2) long-term effectiveness that would be provided by the alternatives; and 3) estimated attainment of ARARs for each alternative. Modeling results are used in the comparisons to contrast the two threshold criteria of "overall protection of human health and the environment" and "compliance with ARARs." The primary balancing criteria are also compared; however, the evaluation of each of these criteria is very similar due to the technical similarities in the alternatives themselves, with the exception of costs. Table 9-1 presents a summary of the alternatives with respect to the first seven NCP evaluation criteria.

Under the current site conditions, several surface water and groundwater quality ARARs are exceeded (see Sections 3.1.3.4 and 3.1.3.5). The most logical approach to improve both surface water and groundwater quality at the site is to remove the mine waste sources from the active channel and floodplain of Snowshoe Creek. This action would also result in eliminating mine wastes from being in direct contact with groundwater. Other significant human health and ecologic risks posed by the site are in the form of large surface areas of exposed wastes available for direct contact and soil ingestion by humans and other ecologic receptors, and phytotoxic concentrations of metals at the surface of the wastes.

Due to the reasons briefly described above, only two action Alternatives (4a and 4b) were retained for detailed analysis for the Snowshoe Mine Site, and both are very similar to one another. Alternatives 3a and 3b were not retained for detailed analysis because neither of these alternatives involved removal of the waste sources from the active channel and floodplain of Snowshoe Creek. Implementation of these alternatives would result in very limited risk reduction at the site; and cost to implement either Alternative 3a or 3b would still be significant. Although Alternative 5 would provide a high degree of risk reduction at the site, it was not retained for detailed analysis due to being cost prohibitive.

Alternatives 4a and 4b both include disposal of the highest risk waste sources at the site in a constructed repository. Under Alternative 4a, the tailings would be completely excavated and disposed in the repository, WR-4 would be contained in-place, and no action would be implemented for the upper waste rock dumps (WR-1, WR-2 and WR-3). Under Alternative 4b, the tailings and WR-4 would be completely excavated and disposed in the repository, and an access road would be constructed to the upper waste rock dumps (WR-1, WR-2 and WR-3) so that they could be contained in-place. Under both alternatives, three repository design options were considered, as follows:

- Design Option 1 – Repository consisting of a simple cover soil cap (24 inches thick);
- Design Option 2 – Repository consisting of a multi-layered (impermeable) cap; and
- Design Option 3 - Repository consisting of a composite bottom liner with integral leachate collection/removal system, also with a multi-layered cap.

TABLE 9-1: COMPARATIVE ANALYSIS OF ALTERNATIVES

Assessment Criteria	**Alternative 1:** No Action	**Alternative 4a (Repos. Design Option 1):** Removal/Disposal of Tailings in a Constructed Repository and In-Place Containment of WR-4 (Repository with Cover Soil Cap)	**Alternative 4a (Repos. Design Option 2):** Removal/Disposal of Tailings in a Constructed Repository and In-Place Containment of WR-4 (Repository with Multi-Layered Cap)	**Alternative 4a (Repos. Design Option 3):** Removal/Disposal of Tailings in a Constructed Repository and In-Place Containment of WR-4 (Repository with Bottom Liner, Leachate Collection System and Multi-Layered Cap)	**Alternative 4b (Repos. Design Option 1):** Removal/Disposal of Tailings and WR-4 in a Constructed Repository and In-Place Containment of Remaining Waste Sources (Repository with Cover Soil Cap)	**Alternative 4b (Repos. Design Option 2):** Removal/Disposal of Tailings and WR-4 in a Constructed Repository and In-Place Containment of Remaining Waste Sources (Repository with Multi-Layered Cap)	**Alternative 4b (Repos. Design Option 3):** Removal/Disposal of Tailings and WR-4 in a Constructed Repository and In-Place Containment of Remaining Waste Sources (Repository with Bottom Liner, Leachate Collection System and Multi-Layered Cap)
Overall Protectiveness of Public Health Safety and Welfare -	No reduction in risk.	Removal/Disposal of tailings and in-place containment of WR-4 is expected to reduce human health risk by 61%.	Removal/Disposal of tailings and in-place containment of WR-4 is expected to reduce human health risk by 64%.	Removal/Disposal of tailings and in-place containment of WR-4 is expected to reduce human health risk by 64%.	Removal/Disposal of tailings and in-place containment of WR-4 is expected to reduce human health risk by 82%.	Removal/Disposal of tailings and in-place containment of WR-4 is expected to reduce human health risk by 86%.	Removal/Disposal of tailings and in-place containment of WR-4 is expected to reduce human health risk by 86%.
Environmental Protectiveness	No protection offered.	Removal/Disposal of tailings and in-place containment of WR-4 is expected to reduce ecological risk by 81%.	Removal/Disposal of tailings and in-place containment of WR-4 is expected to reduce ecological risk by 83%.	Removal/Disposal of tailings and in-place containment of WR-4 is expected to reduce ecological risk by 83%.	Removal/Disposal of tailings and in-place containment of WR-4 is expected to reduce ecological risk by 91%.	Removal/Disposal of tailings and in-place containment of WR-4 is expected to reduce ecological risk by 94%.	Removal/Disposal of tailings and in-place containment of WR-4 is expected to reduce ecological risk by 94%.
Compliance with ARARs -							
Chemical Specific	Several chemical-specific ARARs are exceeded in surface water and groundwater.	ARARs do not apply to containment of contaminated solid media. All surface water ARARs would be achieved; HHS for Cd and Pb would be exceeded in on-site groundwater and HHS for Pb would be exceeding in repository area groundwater.	ARARs do not apply to containment of contaminated solid media. All surface water ARARs would be achieved; HHS for Cd and Pb would be exceeded in on-site groundwater.	ARARs do not apply to containment of contaminated solid media. All surface water ARARs would be achieved; HHS for Cd and Pb would be exceeded in on-site groundwater.	ARARs do not apply to containment of contaminated solid media. All surface water ARARs would be achieved; HHS for Cd and Pb would be exceeded in on-site groundwater.	ARARs do not apply to containment of contaminated solid media. All surface water ARARs would be achieved; HHS for Cd and Pb would be exceeded in on-site groundwater.	ARARs do not apply to containment of contaminated solid media. All surface water ARARs would be achieved; HHS for Cd and Pb would be exceeded in on-site groundwater.
Location Specific	None Apply	All location-specific ARARs would be met.	All location-specific ARARs would be met.	All location-specific ARARs would be met.	All location-specific ARARs would be met.	All location-specific ARARs would be met.	All location-specific ARARs would be met.
Action Specific	None Apply	All action-specific ARARs would be met.	All action-specific ARARs would be met.	All action-specific ARARs would be met.	All action-specific ARARs would be met.	All action-specific ARARs would be met.	All action-specific ARARs would be met.
Long-Term Effectiveness and Permanence -							
Magnitude of Residual Risk	No reduction in CoC levels in any environmental media, except by natural degradation/erosion.	Level of risk reduction would not be sufficient to attain recreational use goals for the site.	Level of risk reduction would not be sufficient to attain recreational use goals for the site.	Level of risk reduction would not be sufficient to attain recreational use goals for the site.	Level of risk reduction would not be sufficient to attain recreational use goals for the site.	Level of risk reduction would not be sufficient to attain recreational use goals for the site.	Level of risk reduction would not be sufficient to attain recreational use goals for the site.
Adequacy and Reliability of Controls	No controls over any on-site contamination. Potential for catastrophic failure of tailings impoundment.	Containment controls are adequate for intended purpose; removal of waste sources from Snowshoe Creek ensures long-term reliability.	Containment controls are adequate for intended purpose; removal of waste sources from Snowshoe Creek ensures long-term reliability.	Containment controls are adequate for intended purpose; removal of waste sources from Snowshoe Creek ensures long-term reliability.	Containment controls are adequate for intended purpose; removal of waste sources from Snowshoe Creek ensures long-term reliability.	Containment controls are adequate for intended purpose; removal of waste sources from Snowshoe Creek ensures long-term reliability.	Containment controls are adequate for intended purpose; removal of waste sources from Snowshoe Creek ensures long-term reliability.
Reduction of Toxicity, Mobility and Volume -							
Treatment Process Used and Materials Treated	None.	Removal of tailings material to repository and in-place containment of WR-4 is expected to provide significant reduction in mobility of CoCs from wind and water erosion as well as infiltration.	Removal of tailings material to repository and in-place containment of WR-4 is expected to provide significant reduction in mobility of CoCs from wind and water erosion as well as infiltration.	Removal of tailings material to repository and in-place containment of WR-4 is expected to provide significant reduction in mobility of CoCs from wind and water erosion as well as infiltration.	Removal of tailings material to repository and in-place containment of WR-4 is expected to provide significant reduction in mobility of CoCs from wind and water erosion as well as infiltration.	Removal of tailings material to repository and in-place containment of WR-4 is expected to provide significant reduction in mobility of CoCs from wind and water erosion as well as infiltration.	Removal of tailings material to repository and in-place containment of WR-4 is expected to provide significant reduction in mobility of CoCs from wind and water erosion as well as infiltration.
Volume of Contaminated Materials Treated	No reduction in CoC toxicity, mobility or volume.	No volume actively treated; however, approx. 97,000 cy removed from floodplain and isolated from human and environmental receptors.	No volume actively treated; however, approx. 97,000 cy removed from floodplain and isolated from human and environmental receptors.	No volume actively treated; however, approx. 97,000 cy removed from floodplain and isolated from human and environmental receptors.	No volume actively treated; however, approx. 135,000 cy removed from floodplain and isolated from human and environmental receptors.	No volume actively treated; however, approx. 135,000 cy removed from floodplain and isolated from human and environmental receptors.	No volume actively treated; however, approx. 135,000 cy removed from floodplain and isolated from human and environmental receptors.
Expected Degree of Reduction	Minimal, via natural degradation only (potential for future increases in mobility of contaminants	Volume or toxicity of CoCs would not be reduced; however, significant reduction in mobility is expected.	Volume or toxicity of CoCs would not be reduced; however, significant reduction in mobility is expected.	Volume or toxicity of CoCs would not be reduced; however, significant reduction in mobility is expected.	Volume or toxicity of CoCs would not be reduced; however, significant reduction in mobility is expected.	Volume or toxicity of CoCs would not be reduced; however, significant reduction in mobility is expected.	Volume or toxicity of CoCs would not be reduced; however, significant reduction in mobility is expected.
Short-Term Effectiveness -							
Protection of Community During Reclamation Action	Not applicable.	Fugitive emissions control may be required during construction	Fugitive emissions control may be required during construction	Fugitive emissions control may be required during construction	Fugitive emissions control may be required during construction	Fugitive emissions control may be required during construction	Fugitive emissions control may be required during construction
Protection of On-Site Workers During Reclamation Action	Not applicable.	Expected to be sufficient. Safety hazards likely more prevelant than hazards associated with wastes.	Expected to be sufficient. Safety hazards likely more prevelant than hazards associated with wastes.	Expected to be sufficient. Safety hazards likely more prevelant than hazards associated with wastes.	Expected to be sufficient. Safety hazards likely more prevelant than hazards associated with wastes.	Expected to be sufficient. Safety hazards likely more prevelant than hazards associated with wastes.	Expected to be sufficient. Safety hazards likely more prevelant than hazards associated with wastes.
Environmental Impacts	Same as baseline conditions.	Surface water impacts possible due to construction activities in active stream channel and floodplain of Snowshoe Creek.	Surface water impacts possible due to construction activities in active stream channel and floodplain of Snowshoe Creek.	Surface water impacts possible due to construction activities in active stream channel and floodplain of Snowshoe Creek.	Surface water impacts possible due to construction activities in active stream channel and floodplain of Snowshoe Creek.	Surface water impacts possible due to construction activities in active stream channel and floodplain of Snowshoe Creek.	Surface water impacts possible due to construction activities in active stream channel and floodplain of Snowshoe Creek.
Time Until Reclamation Objectives are Achieved	Not applicable.	One field season.	One field season.	One field season.	One field season.	One field season.	One field season.
Implementability -							
Ability to Construct and Operate	No construction or operation involved.	Moderately difficult to implement due to remote location, steepness of terrain, and need to work with wet tailings.	Moderately difficult to implement due to remote location, steepness of terrain, and need to work with wet tailings.	Moderately difficult to implement due to remote location, steepness of terrain, and need to work with wet tailings.	Moderately difficult to implement due to remote location, steepness of terrain, and need to work with wet tailings.	Moderately difficult to implement due to remote location, steepness of terrain, and need to work with wet tailings.	Moderately difficult to implement due to remote location, steepness of terrain, and need to work with wet tailings.
Ease of Implementing More Action if Necessary	Not applicable.	Easily implementable (additional armoring/stabilization, etc), if determined necessary.	Easily implementable (additional armoring/stabilization, etc), if determined necessary.	Easily implementable (additional armoring/stabilization, etc), if determined necessary.	Easily implementable (additional armoring/stabilization, etc), if determined necessary.	Easily implementable (additional armoring/stabilization, etc), if determined necessary.	Easily implementable (additional armoring/stabilization, etc), if determined necessary.
Availability of Services and Capacities	Not applicable.	Available locally and within the state.	Available locally and within the state.	Available locally and within the state.	Available locally and within the state.	Available locally and within the state.	Available locally and within the state.
Availability of Equipment and Materials	Not applicable.	Available locally and within the state.	Available locally and within the state.	Available locally and within the state.	Available locally and within the state.	Available locally and within the state.	Available locally and within the state.
Estimated Capital Cost	**$0.00**	**$1,647,279.00**	**$1,842,004.00**	**$2,066,979.00**	**$2,073,895.00**	**$2,346,901.00**	**$2,662,257.00**

Alternatives 4a and 4b are expected to provide similar protectiveness of human health and the environment (when comparing similar design options for the repository among each alternative). Each of these alternatives would comply with all action-specific and location-specific ARARs; however, neither alternative is expected to comply with all chemical-specific ARARs. Implementing either Alternative 4a or 4b would result in compliance with all chemical-specific surface water ARARs in Snowshoe Creek; however, HHSs may continue to be exceeded for cadmium and lead in on-site groundwater because neither alternative involves removal of the upper waste rock dumps, and these sources would continue to provide limited contaminant loading to groundwater. This may not be a major concern provided that groundwater at the site is not used as a source for drinking water in the future.

Only repository Design Options 2 and 3 under either Alternative 4a or 4b, is expected to comply with all chemical-specific ARARs for groundwater at the repository site. Modeling results indicate that the HHS for lead may be exceeded in groundwater beneath the repository site for Design Option 1 (under either alternative) due to continued leaching of the wastes contained in the repository. Repository Design Options 2 and 3 adequately mitigate leaching of the waste materials within the repository to attain all chemical-specific ARARs for groundwater at the repository site.

Neither Alternative 4a nor 4b is expected to provide sufficient risk reduction over the long term to meet the requirements of the risk assessment for the recreational use scenario. This is due to the standard risk assessment assumption that the covers or caps installed over the mine wastes may deteriorate over time creating a pathway for human exposure via soil ingestion. Only Alternative 5 is expected to comply with all chemical-specific ARARs and risk reduction goals for the site; however, at an estimated cost of over $30,000,000.00 to implement, Alternative 5 is considered cost prohibitive.

Under neither of the alternatives (4a or 4b) would the wastes actually be treated to reduce contaminant volume or toxicity; both alternatives would provide very similar (and significant) degrees of reduction in contaminant mobility. The short-term effectiveness is expected to be similar for each of the alternatives. The alternatives are both technically similar, and the construction steps required to implement them would be similar as well. It is anticipated that either of the alternatives could be completed in a single construction season.

Short-term impacts to the surrounding community would likely not be significant under either alternative due to the remoteness of the site. Short-term impacts to the surrounding community would involve increased local vehicle traffic on public roadways and associated safety hazards, as well as increased noise levels and dust generation. Short-term impacts to environmental resources are difficult to quantify; however, every effort would be made to minimize impacts to Snowshoe Creek and potential downstream receptors during implementation of either of the alternatives. Additionally, BMPs would be required to be implemented during construction to protect surface water resources.

The implementability of both alternatives is expected to be similar, with the exception of constructing a new haul road to access the upper waste rock dumps (WR-1, WR-2, and WR-3) under Alternative 4b. Due to the extremely steep topography of the area, the road would necessarily include several switchbacks and would need to be approximately 5,000 feet in total length to provide a suitable grade for construction equipment. The road would also include in-sloping and construction of a continuous safety berm in compliance with MSHA regulations. Construction of this road would be a major endeavor and would require a large investment in both time and capital under Alternative 4b. The large difference in cost between Alternative 4a and Alternative 4b (on the order of $500,000.00 when comparing similar design options for the repository among each alternative) can be attributed to construction of this road and needing to haul a fairly large quantity of lime, cover soil and other materials to the upper waste rock dumps.

Both alternatives use conventional design and construction techniques; however, the construction steps required to implement either of the alternatives are considered moderately difficult due to the need to divert Snowshoe Creek, dewater the tailings, and work on steep slopes. As previously stated, Alternative 4b would involve significantly more work on steep slopes than Alternative 4a.

Construction methods to excavate and transport the tailings materials will likely be problematic (applicable to both alternatives) due to abundant groundwater within the floodplain of Snowshoe Creek. High moisture content within the tailings material will result in low shear strength of the material and will reduce productivity of the construction equipment. Consequently, alternative methods for excavating the tailings materials may be necessary. Alternative methods may include constructing temporary "bridging" roads and/or benches across the tailings impoundment to allow access for continued excavation. Additionally, use of specialized low ground pressure (LGP) equipment and/or a conveyor belt system may be necessary.

For ease of construction, Alternative 4a would be less cumbersome to implement because it does not involve construction of a new haul road to access the upper waste rock dumps. Either of the alternatives would require the import of a significant amount of cover soil and development/management of the repository/borrow area; materials availability and scheduling of delivery may make either alternative somewhat difficult to implement.

Table 9-1 indicates the estimated cost associated with each alternative and briefly summarizes each alternative in relation to the seven NCP criteria. Table 9-2 summarizes the estimated cost per unit risk reduction for each alternative.

TABLE 9-2
ALTERNATIVE COST-EFFECTIVENESS COMPARISON SUMMARY

ALTERNATIVE	OVERALL RISK REDUCTION	ESTIMATED COST	COST PER 1% REDUCTION IN RISK
Alternative 4a (Repository Design Option 1)	71%	$1,647,279	$23,201
Alternative 4a (Repository Design Option 2)	74%	$1,842,004	$24,892
Alternative 4a (Repository Design Option 3)	74%	$2,066,979	$27,932
Alternative 4b (Repository Design Option 1)	86%	$2,073,895	$24,115
Alternative 4b (Repository Design Option 2)	90%	$2,346,901	$26,077
Alternative 4b (Repository Design Option 3)	90%	$2,662,257	$29,581

Table 9-2 shows that there is a fairly wide range in overall risk reduction and cost-effectiveness provided by each of the alternatives. Repository Design Option 1 (applicable to both Alternatives) appears to be the most cost-effective option for construction of a repository at the site. However, modeling results indicate that the HHS for lead may be exceeded in groundwater beneath the repository (where there are currently no groundwater problems) if Design Option 1 were implemented under either alternative.

Alternative 4a (Repository Design Option 2) is the next most cost-effective alternative considered for the site. This alternative would provide identical overall risk reduction as Alternative 4a (Repository Design Option 3), yet is estimated to be $225,000.00 less costly to implement. Although Alternative 4a (Repository Design Option 2) provides 16% less risk reduction than the comparable repository design option under Alternative 4b, Alternative 4a is estimated to cost nearly 30% less ($505,000.00) than Alternative 4b.

10.0 PREFERRED ALTERNATIVE

Based on the conclusions of the detailed analysis and comparative analysis of alternatives, Alternative 4a: Removal/Disposal of Tailings in a Constructed Repository (Repository Design Option 2) and In-Place Containment of WR-4 is recommended as the preferred alternative for the Snowshoe Mine Site. In summary, this Alternative involves excavation and disposal of the tailings (approximately 97,000 cubic yards) in a constructed repository and in-place containment of WR-4. No action would be implemented for the upper waste rock dumps (WR-1, WR-2, and WR-3). The two open adits located in the vicinity of the upper waste rock dumps would be closed using bat-friendly grates. The repository would be constructed at Site B-1 (Figures 3-4 and 3-7) and would consist of a multi-layered (impermeable) cap with no bottom liner system (Figure 7-2).

Excavation of the tailings would require temporary diversion of Snowshoe Creek and would involve extensive dewatering of the excavation area. Following removal of the tailings, the resulting excavated footprint would be covered with a minimum of 12 inches of cover soil followed by revegetation. Removal of the tailings would also result in complete elimination of the existing streambed, channel and floodplain of Snowshoe Creek; consequently, Snowshoe Creek would need to be reconstructed along its original (pre-mining) alignment. Alternatively, depending on the site conditions following excavation of the tailings, an alpine lake/pond could possibly be constructed in the tailings excavation area. WR-4 would be contained in-place by grading, amending with lime (as necessary), covering with a minimum of 12 inches of cover soil, and revegetating. Due to the steepness of the lower (northern) portion of WR-4, this section of the dump would also be covered with erosion control mat. Additionally, the eastern edge of WR-4, located in close proximity to an intermittent drainage, would be armored with riprap. This alternative is projected to reduce human health risk at the site by 64% and ecological risk by 83% (approximately 74% overall risk reduction). The alternative would comply with all action-specific and location-specific ARARs; however, HHSs may continue to be exceeded for cadmium and lead in on-site groundwater due to the upper waste rock dumps continuing to provide some contaminant loading to groundwater. This may not be a major concern, however, if the groundwater at the site is not used as a source for drinking water in the future.

Alternative 4a is not expected to provide sufficient risk reduction over the long term to meet the requirements of the risk assessment for the recreational use scenario. This is due to the standard risk assessment assumption that the covers or caps installed over the mine wastes may deteriorate over time creating a pathway for human exposure via soil ingestion. However, if the reclaimed site is routinely monitored and adequate maintenance is implemented when necessary, sufficient risk reduction would be achieved.

Due to existing heavy timber at the proposed repository site (Site B-1, evaluated by MAXIM), the site has not yet been surveyed. Prior to implementing construction activities, approximately 5 acres of timber would need to be harvested from the proposed repository location. After the timber is cleared, a detailed topographic survey of the area would need to be performed to be able to complete the repository design and calculate construction quantities, etc.

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